THE

ENGINEERING MAGAZINE

VOL. VII. AUGUST, 1894. No. 5.

OUR ENORMOUS ANNUAL LOSS BY FIRE.

A WASTE BORN OF IGNORANCE AND NEGLECT.

By Edward Atkinson.

THE waste of property by fire is increasing year by year, in undue proportion to the increase of property at risk. Last year's ash-heap in the United States has been computed in excess of $150,000,000. In order to ascertain the true measure of the fire-tax we must add to this some $60,000,000 to $70,000,000 as the cost of sustaining insurance companies, by which a part of the loss is distributed throughout the community. To this again must be added the cost of sustaining fire-departments, which came to $25,000,000 some years ago, when I first investigated this subject. Thus the measure of this fire-tax in the past year cannot have been less than $250,000,000. That is the penalty which we pay for ignorance, stupidity, carelessness, and crime, for which the responsibility must be distributed mainly among owners of buildings, though shared in part by occupants, architects, and builders.

Is there no remedy except further destruction? That this ruin may be remedied has been made plain in many ways. That it may be remedied in large measure without the excessive cost of what is called "fire-proof construction" has been fully proved by long experience in building, and in protecting and saving from loss what have become known as the "slow-burning factories and workshops" in the eastern and middle United States. These slow-burning methods of construction have been widely extended of late throughout the west. Great changes have occurred lately in the sense of responsibility for loss by fire. Owners have become aware that the bad methods of combustible architecture are costly and wasteful, and that they are themselves in fault for their adoption. Many architects of repute have made plans

Copyright, 1894, by the Engineering Magazine Company.

and are prepared to meet the demand for slow-burning construction at moderate cost. Builders are being held to a sense of their responsibility to the end that they may no longer permit careless workmen to sweep shavings into the spaces of the hollow floors where they have heretofore been left, resting upon the ceilings of the rooms below. There is yet a vast deal of work to be done, especially in the education of real-estate owners. To that end the writer has again undertaken to treat this question in the light of his later experience.

It is not many years since I predicted the end of the system of "combustible architecture," as I then named the common practice of building, at which end we have about arrived. Insurance companies have gradually realized that betting that bad risks will not burn and paying high commissions for the sake of getting a small wager is a bad business. Many have failed; others have been wound up; the survivors are now taking the only safe and judicious course,—namely, writing risks only according to the measure of hazard, insisting upon adequate premiums (which in many instances are not yet high enough), enforcing frequent inspections, and refusing to insure any considerable amount in a great many sections of cities, especially upon some of the costly examples of combustible architecture which are still very numerous. This course of the underwriters brings the responsibility where it belongs: upon the owners of unsafe buildings, who, finding themselves unable to let their property because their tenants cannot procure insurance, are now trying to find the remedy which they might long ago have anticipated.

At one time the writer transferred to the pages of the *Century* magazine some of the data of the experience of the factory underwriters of New England, under the title of "Slow-Burning Construction." Strangely enough many men, themselves large owners or occupants of combustible warehouses in cities, held at the same time positions as directors or members in factory mutual insurance companies carrying risks on textile factories, paper-mills, machine-shops, and other similar works of a hazardous and sometimes of an extra-hazardous kind. In the conduct of these insurance companies they soon came to a very clear sense of the fire hazard. The main object of the work of the factory mutual underwriters is to prevent loss by fire; the secondary purpose being to pay indemnity for loss when it occurs. The underwriters hold the owner or manager of the factory to a strict account in explanation of the reason why any loss may have occurred, nearly all losses being traceable to some fault either in construction or on the part of the occupant. When that rule is applied to hospitals, asylums, churches, schoolhouses, and city warehouses and shops, they may be made fit to insure, and not before.

In the direction of this work it became apparent to the officers of these factory mutual insurance companies (1) that there is no such thing as a fireproof factory-building and (2) that if there were it would cost too much to construct it. In a great many buildings constructed in Europe for textile purposes, commonly known as "fireproof factories," the combustion of the contents has frequently occasioned complete destruction. They are merely buildings made of incombustible materials—usually brick and iron. Iron is one of the most treacherous of all building materials when suddenly exposed to a high heat.

In the course of a long period the slow-burning factory-building was evolved under the supervison of the underwriters, and the publication in the *Century* magazine of the principles of slow-burning construction exerted, throughout the country, a very powerful influence on industrial architecture. In many instances, however, these principles of construction were so little comprehended and were so perverted in practice that buildings which were ostensibly slow-burning were really liable to the most rapid destruction by fire.

The growing evil of our present fire-tax and the excessive loss to which reference has been made must be stopped. If it is not stopped soon, adequate insurance on any and all city warehouses will become impossible. The evil is not in the expense of conducting the insurance business, although under ordinary conditions that is a very heavy charge. The present trend toward what are called Lloyds associations and the organization of the mutual insurance companies for the purpose of giving contracts of indemnity on city buildings may end in yet greater disaster; it surely will so end if it puts off the only method of meeting the evil by improving the risks.

Reference has been made to the perversion of the slow-burning principle. I may venture to describe what it is and what it is not, after which I will proceed to deal with other elements in this case.

The system of mill-construction should be considered as a whole by an architect who undertakes to apply it; otherwise grave errors may be made. The very title which I have given it myself—"slow-burning construction"—would sufficiently indicate to any thoughtful person that mill-construction did not consist simply or wholly in laying floors or roofs of thick planks on heavy timbers, spaced widely apart. That is but one element in slow-burning or mill construction. It goes without saying that wide and exposed surfaces of wood, however disposed, may burn rapidly under almost any conditions, *if not suitably protected;* such buildings will surely burn rapidly if so finished as to promote the rapid spread of fire upon or under such wooden surfaces, without any provision for stopping such fires.

No advocate of mill-construction pretends that there are not ex-

amples of so-called fireproof construction which will burn more slowly, or which will be destroyed by fire more slowly, than any possible construction of wooden timber and plank. But, as I have said, the extra cost of this type of construction in many instances may be saved.

The motive of mill-construction is economy as well as safety. There are many classes of business that will not bear the heavy cost of a more strictly fireproof method of construction. Moreover, the factory of approved mill-construction has proved to be so safe as a whole, and such factories have been covered by mutual insurance at so little cost, as to render it wholly inexpedient or even unnecessary for the owners of textile factories and workshops to take any other method into consideration.

For instance, wherever the mill-floor, suitably constructed of three-inch plank, grooved and splined, covered with one-inch top boarding, laid on timbers eight or ten feet on centers, has been made continuous,—that is to say, without any break for belt-holes, open elevators, or open stairways,—it has never been burned through by a fire upon the floor or by fire passing through the floor above, except in one instance, and that was in a warehouse where a pile of jute bales took fire in a place where it could not be reached. The firemen then put water through the hole from open butts and drowned it out. Fires on such mill-floors have been held, not only in the building, but in the room where they originated.

Again, iron posts have been crippled or sprung by heat a great many times at an early period in a fire. A wooden post of suitable size has never burned off until other parts of the building were already destroyed. They have in one instance resisted for hours fire which destroyed granite posts near them by reducing them to sand—the granite measuring 12 by 12 inches. In this instance oak posts were put in between the original posts of granite to bear an added weight of machinery. When the fire came the oak sustained the whole load.

To repeat, the mill-floor properly constructed and rightly guarded has sufficed to hold fires, not only in the building but in the room in which they have originated, until the mill fire-department or the public fire-department could extinguish the fire. The wooden mill-post of suitable size will last longer than the floor. The mill-floor possesses this very great advantage over the ordinary joisted floor: Fires may be readily swept away between the timbers either by sprinklers or by water from hose-pipes; while in the joisted floor or floor laid over plank on edge, 18 inches to 24 inches apart on centers, the fire will burn on one side of the joist or plank while the water is playing on the other side.

Lest this mode of construction should be subjected to prejudice

through ignorance, I will now state what mill-construction is and what it is not.

WHAT MILL-CONSTRUCTION IS.

I. Mill-construction consists in so disposing the timber and plank in heavy solid masses as to expose the smallest number of corners or ignitable projections to fire, to the end also that when fire occurs it may be most readily reached by water from sprinklers or hose.

II. It consists in separating every floor from every other floor by incombustible stops,—by automatic hatchways, by encasing stairways either in brick or other incombustible partitions,—to the end that a fire shall be retarded in passing from floor to floor to the utmost that is consistent with the use of wood or any material in construction that is not absolutely fireproof.

III. It consists in guarding the ceilings over all specially hazardous stock or processes with plastering laid on wire lath or upon dovetailed lath or by plaster board of a suitable kind, following the lines of the ceiling and of the timbers without any interspaces between the plastering and the wood ; or else in protecting ceilings over hazardous places with tin or other suitable metal, but not with zinc.

IV. It consists not only in so constructing the mill, workshop, or warehouse that fire shall pass as slowly as possible from one part of the building to another, but also in providing all suitable safeguards against fire.

V. It consists in laying the top floor and the outer boarding of the roof *over mortar*, plaster-board, or some other fire-retardent between it and the plank, where the maximum of safety is to be attained.

WHAT MILL-CONSTRUCTION IS NOT.

I. Mill-construction does *not* consist in disposing a given quantity of materials so that the whole interior of a building becomes a series of wooden cells ; being filled with concealed spaces, either directly connected each with the other or by cracks through which fire may freely pass where it cannot be reached by water. That is the common practice now named "combustible architecture."

II. It does *not* consist in an open-timber construction of floors and roof resembling mill-construction, but of light and insufficient size in timbers and thin planks, without fire-stops or fire-guards from floor to floor.

III. It does *not* consist in connecting floor with floor by combustible wooden stairways encased in wood.

IV. It does *not* consist in putting in very numerous divisions or partitions of light wood.

V. It does *not* consist in sheathing brick walls with wood, espe-

cially when the wood is set off from the wall by furring, even if there are stops behind the furring.

VI. It does *not* consist in permitting the use of varnish upon woodwork over which a fire will pass with the speed of a race-horse.

VII. It does *not* consist in leaving windows exposed to adjacent buildings unguarded by fire-shutters.

VIII. It does *not* consist in permitting the storage of very combustible goods without protecting the ceilings with solid plastering, plaster-board, or metal.

IX. It does *not* consist in leaving even the best constructed building in which dangerous occupations are followed without automatic sprinklers and without a complete and adequate equipment of pumps, pipes, and hydrants.

X. It does *not* consist in using any more wood in finishing the building after the floors and roof are laid than is absolutely necessary, there being now many safe methods available at low cost for finishing walls and constructing partitions with slow-burning or incombustible material.

I may name, by the way, the use of fine ribbed glass, twenty-one ribs to the inch, which is now coming into use for glazing factory-windows. This ribbed glass diffuses light, stops the glare, and prevents the heavy shadows from sunlight from passing through clear glass.

There are other slow-burning methods of construction which are practised in Europe, of which we have as yet little knowledge. In my own practice, I am called upon to deal only with the construction of factories and workshops. I have therefore never given that close attention to the construction of floors in the low-priced or low-cost buildings of Europe which might well be given to it. I have observed in passing many methods of constructing floors in cheap dwelling-houses and in low-cost structures, in both England and France, of which owners, architects, and builders in the United States appear to be totally ignorant.

There are many methods of combining coal-ashes and plaster in a substance known in England as "breeze," which is filled in between wooden or light iron joists I have asked many architects what "breeze" was, and I think I have never found but one who could answer the question.* There is also a method of incorporating thin hoop-iron set edgewise with incombustible material, which is supposed to be effective in strength and safety.

My attention has been called to other ways of making ordinary

*The accident at the "Shoreham," in Washington, two years ago, was caused by the attempt, improperly carried out, to make a fireproof floor by the use of this same "breeze."
E. A.

buildings slow-burning, but time has not sufficed for me to deal with this branch of work. Many of these foreign methods are available here, although we have not the advantage of the soft stone so common on the European continent, which cuts almost like cheese and hardens like iron. If it came within the scope of factory mutual insurance to investigate this matter I should long ago have made a complete study of the subject.

If the young architects who are sent out on traveling-scholarships, or who pass one or two years in Europe at the École des Beaux-Arts, would forego for a time the fine-art study—of which nearly all foreign types are for many reasons wholly out of place in America—and would devote themselves to the prosaic study of how to construct a slow-burning floor in a dwelling-house at low cost, there might be considerable progress in that branch of architecture which has until recently been so much neglected: the art of building at once safely and inexpensively.

I have so far omitted one caution which I find it always necessary to give to those who are not trained in open-timber or mill construction. It is dangerous to paint, varnish, fill, or encase heavy timbers and thick plank as they are customarily delivered, lest what is called dry-rot should be caused by lack of ventilation or opportunity to season.

It follows that if plastering is to be put upon a ceiling following the line of the under side of the floor and the timber, it should be plain lime-mortar plastering, sufficiently porous to permit seasoning. The addition of the skim-coat of lime putty is hazardous, especially if the top floor is laid upon resin-sized or asphalt paper. This rule applies to almost all timber as now delivered, except to vulcanized timber, which, so far as we yet have evidence, is so fully seasoned by the baking of the albumen in the pores of the wood as to be safely subject to being painted or finished when first put up.

The motive of slow-burning construction is to secure the maximum of well-diffused light, the free circulation of air, and the best ventilation, coupled with immunity from danger of loss by fire so far as that can possibly be accomplished without excessive cost. All these points must of necessity be secured at the minimum of cost, as they have been. The present fair standard of cost is seventy-five cents per square foot of all floors occupied including basement, and under favorable conditions somewhat less. Through the evolution of this type of building and long practice on the part of mill-constructors, the slow-burning factory or work-shop of this type, fully meeting all these conditions, costs less per square foot of floor than the buildings of the ordinary construction, which are devised on the methods of

what I have named "combustible architecture." Our slow-burning factories are not only stronger, but they are safer and better for use in every respect than any other type of building, and they cost less. We have even coped with the hazard of single floors of more than 100,000 square feet in area. The bane of underwriters in cities is the horizontal hazard. All their efforts are directed to securing small areas of floor-surface and they are apt to devote their attention to this element without giving suitable attention to the more dangerous element of the vertical hazard, or of fire passing from one floor to another.

I will explain this vertical hazard by referring to a very customary type of the most unsafe construction that can be devised, to wit, what is commonly called the stone or brick church, such as the Brooklyn Tabernacle, three times destroyed by fire. These churches are complete expressions of the art of combustible architecture. This so-called stone or brick church consists of an outer shell or sham made of incombustible material. Within this is a wooden structure of the cellular order. The hollow floor of the church is fitted with open wooden ways to the cells of the hollow walls; these communicate with the hollow roof, so that when the wooden fire-box customarily attached to the furnace takes fire from a back draft, the fire has a free way through the wooden flues of floor, wall, and roof to the peak, where it usually breaks out, wholly beyond the reach of the firemen. At the first outbreak the fire is usually out of the reach even of an effective fire-department like that of New York.

Reverting to the main subject, there are no more perfect examples of the art of combustible architecture than are to be found in most of the hospitals, asylums, college-buildings, and schoolhouses. I have never been called upon to inspect more dangerous and unsuitable buildings than some of the larger hospitals, especially one for the insane which we were once asked to protect as far as we could. The power of invention had been exhausted in making that building unsafe and unfit for its use, and that has been the common rule rather than the exception down to a very recent period. Of late several hospitals have been built in the same neighborhood, of the solid, slow-burning type, in which there is no concealed space for fire or vermin. This hospital of a true and safe type has also been so constructed as to meet all the requirements of sanitary science at about one-half the customary amount expended in building hospitals of the usual combustible type.

The penalty and the remedy for the practice of combustible architecture in cities are not being severely applied, notably in Boston and, I believe, in many other cities. The writer has predicted from time to time for the last ten years what would ensue. Conflagrations and excessive losses have followed one after another, the ash-heap of each

year exceeding that of the last. This remedy by fire has proceeded until a sufficient number of insurance companies have failed or withdrawn from business to enable the survivors to take effective action for remedying the wrong. Many buildings in Boston are now without tenants because the tenants cannot procure insurance on their contents. The Boston fire-department has distinguished itself for its total incapacity to deal with the fire hazard and the responsibility is now falling where it belongs; namely, (1) on the owners and (2) on the city government, which is so organized or unorganized that no responsibility can be put in the right place in order to secure an effective fire-service. It has therefore seemed to me a good time to call attention again to the simple methods of slow-burning construction, by which we may save a large part of the fire-tax, the measure of which I have attempted to give.

It may be remarked that the highest estimate which has ever been put upon the addition to the annual wealth of the United States, including the rise in the value of land, is $2,000,000,000 a year. That estimate is, in my judgment, excessive, but, assuming that it may be approximately correct and taking one-fourth of that sum as representative of the enhanced value of land, we have a remainder of $1,500,000,000 added to the capital of the country from the products of labor in a given year. Assuming that to have been the addition made last year, it then appears that we burned property equal to 10 per cent. upon this annual saving, and we spent not less than 5 per cent. in a vain and futile effort to save a part of this property or to distribute the loss; yet we call ourselves an intelligent community! I have attributed this loss in varying proportions to stupidity, ignorance, carelessness, and crime, shared also in varying proportions by owners, occupants, architects, and builders. In expressing this verdict, if more severe terms can be found, I think they might be rightly applied.

In a former article in this Magazine* I submitted some plates showing the methods of construction by which the success of the factory mutual underwriters of the more conservative type have reduced the average cost of insurance—losses and expenses—on special hazards, including works which, like some parts of the cotton-mill, are almost explosive in their character, to less than twenty cents a year on each $100 insured for the last ten years. We do not solicit insurance. We limit our work to New England and the middle states, and to the specific classes of risks with which we are familiar. Nearly every one of these risks which is fit to be insured by us within this area is now included in our lines. These plans and specifications have been developed in a long period of time by some of the most skilful and

* On "The Park Place Disaster," November, 1891.

competent mill-engineers and constructors of factory-buildings in the United States. It has simply been my function to bring them into a comprehensive form and to adjust the conditions of all our risks to these types.

The danger of the loss of life from fire in the factories which are insured under our supervision has been wholly removed so far as it rests upon means of escape or avoidance of danger other than mere personal accident. I do not know what the exact statistics of loss of property and life in proportion to number and value of all risks would show ; but, so far as the data at my command give a basis, they prove that the special hazards of textile-factories and paper-mills under our supervision have been so far guarded against as to make them better risks and subject to less danger than the average hospital, asylum, dormitory, or college-building.

When I first began investigating this subject, many years ago, the average destruction of this latter class of buildings was one a month. On a second and later examination it appeared that the masters of combustible architecture had gained heavily on that rate ; the losses were one every two weeks. From the latest data, I believe a further gain has been made, and the customary destruction of this class of buildings is probably one a week, often with the cremation of several inmates. Combustible schoolhouses may also be brought into this comparison, being sometimes destroyed, as lately in Evanston, Illinois, with a heavy loss of life. All these dangerous conditions are remediable at lessening cost of construction by the application of mere common sense to the problem. Under such circumstances I think I am justified in the severity of the words I have selected to describe the present conditions.

THE MODERN BATTLE-SHIP AS A FIGHTING-MACHINE.

By George W. Melville,

Engineer-in-Chief, United States Navy.

IF an author had started to write of fighting-ships a hundred years ago he could not have selected the caption of this article. At that time ships were truly what they are sometimes still called,—gun-platforms and transports for fighting-men. Those were the days of close-range conflicts, when the guns were fired almost with muzzles touching, and many a battle was a hand-to-hand contest decided by mere physical strength, the decks of the ships serving as a field, just as in warfare on shore. The change to existing methods has been very gradual, but the days of "boarding" have gone never to return, because the modern battle-ship has become—not figuratively but in reality—a fighting-machine. The emphasis here is to be laid on the last word, and its significance will become apparent on further consideration.

In the old ships *personnel* was everything; *matériel* was almost nothing. In the modern ships the conditions are almost reversed, and, while *personnel* is still indispensable as the directing power, *matériel* has assumed such importance as almost to dwarf it. To an engineer the consideration of the modern battle-ship is fascinating, for it is his creation throughout. He furnishes the material, he fashions every part, and without him its successful use would be impossible. We have the metallurgical engineer who furnishes the material; the ordnance engineer who makes the guns and armor; the marine engineer who builds the main and auxiliary machinery; the hydraulic engineer who supplies the hydraulic apparatus; the electrical engineer who installs the lighting-plant; and the naval architect who builds the hull, for I count him an engineer as truly as the bridge-builder is one.

Every machine includes a carefully-designed framework adapted to support the moving parts and withstand the stresses coming upon it and the moving parts which make it almost a living thing. The battle-ship answers to this definition exactly. The hull is the framework, and its proper design offers a field for the highest professional skill, while the moving parts are engines of all sorts and sizes and for almost every conceivable purpose.

The hull must be strong enough to carry guns, armor, coal, and machinery, to withstand the stresses due to heavy weather, and it must be almost unsinkable. All these conditions make it a very complicated structure, with its numerous bulkheads and water-tight compartments. It has often been said that a war-ship is a series of compromises, and a study of the differences of opinion of eminent designers even at the present time makes this very clear. Ever since the introduction of armor there has been a steady fight between it and the gun, first one and then the other being ahead. At first it was possible to armor the whole side above water as well as to give special protection to the guns and machinery, but with the progress of ordnance the thickness of armor required to give adequate protection has become so great that it is impossible to armor the vessel throughout her length. This has led to the design of central citadel ships where the armor is concentrated at the middle of the length, protecting guns, magazines, and machinery, leaving the ends almost entirely unprotected. In the great Italian battle-ships this has been carried to the point of confining the protection strictly to the big guns, magazines, and machinery, leaving even portions at mid-length unprotected. Many competent critics contend, however, that such vessels are very vulnerable and that an attack of the unarmored ends by rapid-fire guns in the region of the water-line would speedily let in so much water as to render the vessel unmanageable if, indeed, she did not capsize like the unfortunate *Victoria*.

Probably few except those specially interested in the design of naval vessels have any idea of the weight given to armor in the battle-ship, and the following summary of the distribution of weights in our sea-going battle-ship, the *Iowa*, will be interesting:

	Tons.
Hull and fittings	4540
Protection, including armor, protective deck, and water-excluding material	3630
Armament and fittings and ammunition	1000
Machinery, stores, spare parts, etc	1170
Coal at normal displacement	625
Crew, equipment, outfit, stores, etc	325
Total	11,290

From this it will be seen that almost exactly one-third of the entire weight is given up to protection. The distribution of armor in this vessel is as follows: Protection of the hull against injury to the water-line region is to be secured by a side armor belt 14 inches thick and 7.5 feet deep. The transverse armor at the ends of the belt will be 12 inches thick. Barbettes and turrets for 12-inch guns will have armor 15 inches thick, and the ship's side, from the armor belt to the main deck, will have a thickness of 5 inches. An armored deck, 3 inches thick, is to extend forward and aft from the ends of the armor belt.

The conning-tower will have 10-inch armor, and will be connected to the armored deck by an armored communication-tube 7 inches thick. The barbettes of the 8-inch guns will be 8 inches thick on the exposed side and 6 inches elsewhere, while the turret armor will be 6 inches thick. These turrets will have armored supporting tubes 3 inches thick arranged to protect the ammunition hoists. The 4-inch guns will have shields 4 inches thick.

Thus far we have been considering the defensive side of the fighting-machine, because the battle-ship must be able to receive as well as to give blows. We shall now consider the offensive side or those features which fulfil the idea that the machine is to fight.

Most modern battle-ships include the three great weapons of attack, the gun, the ram, and the torpedo, and each is a machine in itself. Special vessels have been built in which one of the last two is the only weapon, this feature being carried out to the greatest extent in the torpedo-boat, which has been multiplied by the score in the navies of all first-class countries but the United States. Only a few rams, where that is the only weapon, have been built thus far, although that accomplished naval officer, Admiral Ammen, believes that fleets of rams should form our principal class of vessels. In the battle-ship, the ram and the torpedo are regarded as secondary weapons, the main reliance being upon the gun. It is not hard to understand why this should be so. The ram and the torpedo are effective only against other vessels and they must be used at close range, the former by the very nature of things. The gun is effective at long range and against fortifications as well as ships.

At one time it seemed as though the increase in size of guns was to be without limit, and there are actually afloat to-day a number of guns weighing from 100 to 110 tons. This enormous weight, moreover, is that of the gun alone. When its mount and fittings are included the figures would be increased more than half. Experience has shown, however, that this was going too far, and the limit now appears to be about 13.5 inches caliber and 67 tons weight. Only a few full charges, comparatively, can be fired from one of these monster guns before it must be relined at great expense. The exact number is not definitely known, but is put at fewer than fifty. As an exhibition of enormous power, however, the figures for the firing of one of these guns are awe-inspiring. The projectiles weigh nearly a ton and cost about $750. The powder charge is nearly 1000 pounds and costs about $325. The projectile leaves the gun with a velocity of about 2000 feet per second, having an energy of about 50,000 foot-tons.

An interesting test of an Armstrong 110-ton gun was made in 1891 against a Brown armor-plate 7 feet square and 20 inches thick, at the

back of which was a wrought-iron plate 8 inches thick, and both backed by 20 feet thickness of oak beams and 25 feet thickness of granite, concrete blocks, and brick masonry. The gun was 500 feet from the target. The powder charge was 950 pounds; weight of Holtzer armor-piercing projectile 1813 pounds; muzzle velocity 2079 feet per second, giving a striking energy of 54,320 foot-tons. The projectile struck the center of the plate and perforated the compound plate, the wrought-iron plate, the 20 feet of oak backing, 5 feet of granite, 11 feet of concrete, and finally came to rest after going through 6 feet of brick masonry. We must remember, however, that the gun was only 500 feet away and the target rigid. It is very unlikely that such a favorable chance for the gun would occur in a sea fight.

As already remarked, it is now agreed that smaller guns are better adapted to use at sea, and the following comparison, published by the office of naval intelligence at Washington, shows how a smaller gun may equal the effect of the larger one if it give greater velocity to the projectile.

Maker.	Caliber. Inches.	Weight of Gun. Tons.	Weight of Projectile. Pounds.	Muzzle Velocity. Feet per sec.	Pressure in powder chamber. Tons per sq. in.	Total energy. Foot-tons.	Muzzle penetration of wrought iron. Inches.
Armstrong....	16.25	110.5	1800	2148	19.5	57,570	37.98
Krupp.....	15.75	119.	2028	1804	14.7	45,756	30.90
Canet.....	12.60	65.	993	2386	16.1	39,187	31.93

It will be readily understood that such projectiles and charges as these can not be moved by hand-power, and, in fact, everything about these big guns—hoisting the projectile and charge, loading, training, and giving the elevation—is done by machinery. The gun itself with its attachments forms a highly-complicated machine towards whose perfection some of the ablest minds in the engineering world have devoted themselves entirely.

As we descend the scale of sizes, hand-power becomes available, but not directly. Every modern gun, however small, remains a machine, and so true is this that a special class, its members bearing the names of various inventors, has arisen to which the specific designation "machine-guns" has been given. These little weapons make the figurative expression "leaden rain and iron hail" a plain matter of fact. Our own Gatling gun was among the first, but the machine idea seems to have culminated in the Maxim gun, which, when once started, continues to work automatically until the supply of ammunition is ex-

hausted. Intermediate between these and the great guns are the rapid-fire guns, an adaptation to moderate calibers of cartridge ammunition. These are now built up to 6-inch caliber and have practically displaced the ordinary breech-loaders for these sizes. The increase in rapidity of fire is very marked, trials of 6-inch rapid-fire guns having given repeated records of ten aimed shots inside of two minutes, while smaller calibers give still greater rapidity. One record of a 12-centimeter rapid-fire gun showed ten rounds in 54 seconds.

The battery of the *Iowa*, to which reference has already been made, consists of four 12-inch breech-loading rifles; eight 8-inch breech-loading rifles; six 4-inch rapid-fire guns; twenty 6-pounder rapid-fire guns; four 1-pounder rapid-fire guns; four machine-guns; one field gun. The 12-inch guns are to be mounted in two barbette turrets, one forward and one aft on the center-line. The axes of the forward guns, when horizontal, will be 25 feet above the water-line, and those of the after ones nearly 18 feet. The guns of both turrets can fire through an arc of 270 degrees. The 8-inch guns are to be mounted in four barbette turrets, two on each broadside. Their axes will be 25 feet above the water-line and each gun can be trained through an arc of about 170 degrees. The smaller guns are distributed in various parts of the ship, two 1-pounders and the machine-guns being located in the "military tops."

The battery of the *Royal Sovereign*, one of England's finest battle-ships, comprises four 67-ton, 13.5-inch, breech-loading rifles, ten 6-inch rapid-fire guns, twenty-four 6-pounder and 3-pounder rapid-fire guns. The total weight of armament is 4100 tons, and of armor 4550 tons. The armor belt is 250 feet long. The displacement is 14,150 tons as compared with the *Iowa's* 11,290. The latest class of English battle-ships consists of seven vessels of 14,900 tons. They will carry four 12-inch breech-loaders, twelve 6-inch and sixteen 12-pounder rapid-fire guns. From these comparisons it will be seen that the *Iowa* carries a very heavy battery.

Much has been said of the ability of powerful battle-ships armed with heavy guns to shell New York while lying at sea, and it is interesting to note that actual experiment has shown a range for 12-inch guns of over ten miles.

We have now noticed the means for fighting in the battle-ship, but all these costly and intricate machines would be either helpless or useless except for the other machines, down in the bottom of the ship, which furnish the power to these and also give the element of mobility without which the vessel would become simply a fortress on the water.

The boilers are, after all, the most vital element in the ship. Unless they are efficient no degree of excellence elsewhere will avail. It

is little wonder, therefore, that they, as well as the propelling machinery and the magazines, are well protected by heavy armor. They supply not only the main engines but a host of auxiliary engines which have grown in number and importance until, in the modern fighting-machine, this term is almost a misnomer. In the great Italian battle-ships *Re Umberto* and *Lepanto* the main engines are of 19,500 horse-power, while the so-called auxiliaries foot up 2480 horse-power, a considerable fraction.

As in every other part of a modern ship, there has been progress in the design and construction of the boilers. The most familiar type, the cylindrical, has grown in size until one double-ended boiler will be 17 feet in diameter by 21 feet long, weighing, with its contained water, about 140 tons. On board ship weight is precious, and great pressure has been brought on the designers of the main machinery to reduce weights to the lowest point. With the boilers much has been done in this direction by the use of forced draft for the fires, which enables 50 per cent. more power to be obtained on the same weight without undue forcing. Just now we seem on the eve of a radical change in the type of boiler, the new one being composed of many small, thin tubes containing only a little water, so that for the same weight more than double the power can be obtained. The new type of boiler possesses other advantages. It is safer against explosion, it raises steam more quickly, and it can be forced with safety as hard as desired.

As long ago as 1888 the United States navy department took the first steps toward a practical test of boilers of this type under actual service conditions, and the *U. S. S. Monterey* is the first battle-ship whose boilers are largely composed of the water-tube type. All the other countries with great navies are now taking up the subject, and it seems probable that, in a few years, water-tube boilers will form the principal part of the steam-generating plant of all war-vessels.

In past years, the boilers were treated rather badly. The demands of regular service were not severe and the consequences of neglect were not so disastrous. Now, the intelligent and tender care of the boilers is the first thought of the competent engineer.

The propelling engines do not differ greatly in general features from those of the great ocean flyers, but there are many differences of detail. Here, as in the boilers, reduction of weight has been carried as far as possible. This has led to short-stroke, quick-running engines as contrasted with the long-stroke, slow-running ones of the merchant service. This requires greater care and attention to bearings to insure absence of heating. It has also made necessary proportions of cylinders which prevent the attainment of as great economy in the use of steam as obtains in the merchant service. Space forbids an extended considera-

tion here of this very important item, but it may be mentioned that in machinery, as in so many other things about a naval vessel, the existing method is a compromise. Economy is as much desired in naval machinery as in any other, but the most important thing is to get the power in the vessel for as little weight as possible. The two conditions are incompatible, and economy, as the less important, has to yield.

Naval vessels were the first to adopt twin screws generally. Their advantages for a machine built primarily for fighting in greatly increased facility of maneuvering are obvious, as is the additional advantage of offering greater security against total disablement. There are others, such as smaller engines and smaller individual parts, with greater assurance of soundness, that will appeal to any engineer at once.

The auxiliaries have already been mentioned as playing a very important part. Their nature and number is well shown by the following list of those on the *Re Umberto*:

Machines.	Number of machines on board.	I. H. P. (working full power) per machine.	Total power.
Main hydraulic pumps	2	160	320
Auxiliary hydraulic pump	1	80	80
Steering engines	2	100	200
Capstan engine	1	160	160
Steam winches	2	50	100
Dynamo engines	4	25	100
Air-compressing pumps	2	30	60
Fire pumps	2	30	60
Circulating pumps	4	60	240
Main-feed pumps	4	40	160
Auxiliary-feed pumps	6	40	240
Bilge pumps	4	30	120
Air-pumps	2	70	140
Fire-room blowers for forced draft	12	20	240
Ventilating fans	8	10	80
Turning engines	2	25	50
Reversing engines	2	25	50
Pumps for auxiliary condensers	2	20	40
Ash-hoist engines	6	5	30
Workshop engine	1	10	10
Total	69		2,480

From this it appears that there are no less than sixty-nine separate engines, and if the individual cylinders were counted they would exceed 150. The sizes of some of these auxiliaries are very respectable, the main air-pumps and the hydraulic pumps of some of the large ships being actually larger than the propelling-engines of some of the small gunboats. The great amount of steam-piping necessary and the

difficulty of leading it conveniently in all cases have led to the suggestions of driving the auxiliaries by electricity, compressed air or hydraulic power. A careful analysis of the subject by Colonel Nabor Soliani, of the Italian Naval Engineers, shows, however, that steam is both cheaper and involves much less weight than the other methods. Mr. Dickie, manager of the Union Iron Works of San Francisco, has, however, shown that another form of hydraulic transmission, which uses high-speed motors, would weigh as little or less than steam machinery for the auxiliaries.

That the battle-ship is a fighting-*machine* becomes more than ever apparent from considering the list of auxiliaries. Not only does the working of the guns and the supply of ammunition depend on machinery, but the weighing of the anchor, the steering of the vessel, the ventilation, the lighting, the heating, and the cleansing, even the supply of water for drinking and its cooling, all are done by machinery. In fact, the great machine is a steam being, and as long as it is properly fed on its appropriate food, coal, it does its work. That is, when it is in health; but, like human beings, it gets ill and needs its physician, the engineer. It is, however, better treated than human beings, for its physician watches it carefully to see the first signs of anything amiss with the complicated mechanism, and applies the remedy at once.

It may occur to the thoughtful reader to ask why such costly machines as battle-ships are necessary to a navy, and why, if they are necessary, we can not get along with monitors, or small vessels like the *Maine* and the *Texas*, of less than 7000 tons. This question has been debated again and again, and the general agreement is that large battle-ships are necessary. As very cleverly put by Mr. Lewis Nixon, the accomplished naval architect to the Cramps, "You can't get as much fight out of two millions as out of five." In other words, to carry heavy guns to deal heavy blows and to protect them by thick armor so as to be able to stand up against an equally powerful antagonist, we must have a large ship. A small one can't carry the weights. A monitor is an attempt to do this on the least displacement, but she could not fight at sea and she can't carry coal enough to go anywhere. The *Monterey* could not go to Honolulu without carrying coal in bins on deck. She is not meant for that service, however, as she was specially designed for coast-defense.

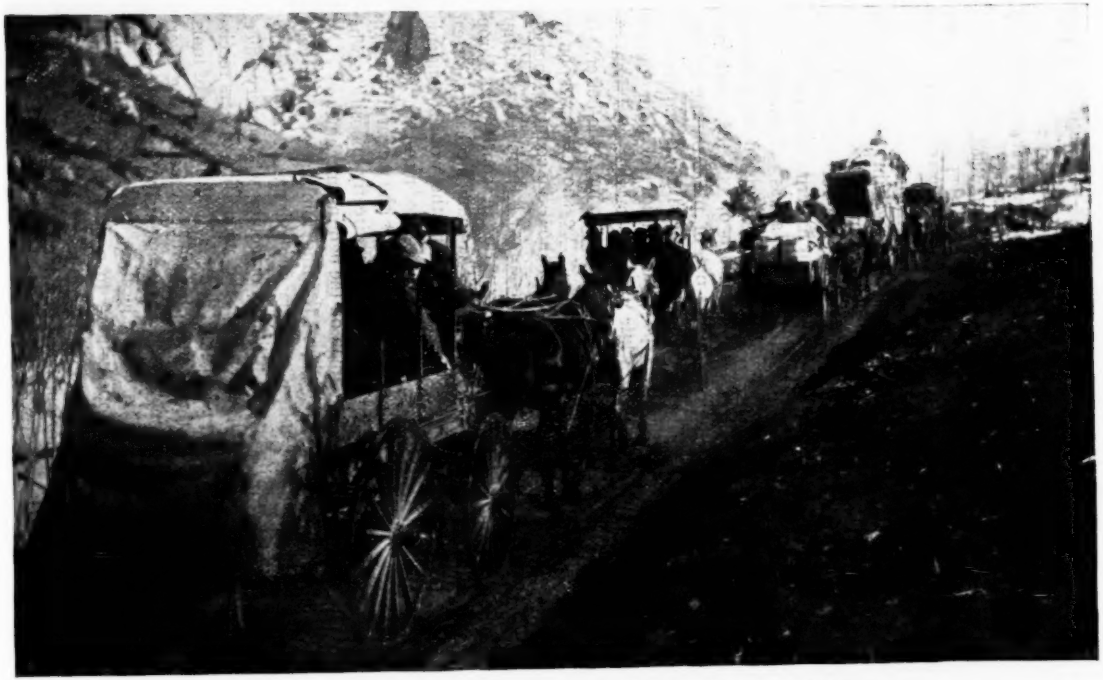
The great fighting-machine is meant to be able to defend the flag anywhere, at home or abroad, and to fight at sea or in harbor. If all nations would agree upon a type of small vessel and limit themselves to that faithfully, then battle-ships might be built smaller or abandoned. Until then, every first-class power must have them. There must, however, be some limit as to size. Sir Nathaniel Barnaby, for many years

the director of naval construction of the British navy, said in a paper last year at the International Engineering Congress:

> I think it also reasonable to say that, excepting a few large and powerful ships, designed, not for line-of-battle but as station ships or naval centers at outlying places of importance, no ship can be regarded as the best ship of war which, being liable to be lost by touching a rock in smooth water, by the attack of a torpedo-boat, by the blow of a ram, or by an internal explosion, may thereby cause the loss of a crew exceeding (say) four hundred men.

In conclusion a few words may be said regarding the appropriate crew of this fighting-machine. For many years it has been the belief that our war-vessels could and would always be recruited in an emergency from the sea-faring population of our eastern coast, notably the fishermen and whalers of New England. This was well enough in the days when sails were an important means of propulsion and guns were the small and simple affairs of thirty years ago, but these men know nothing of machinery and are really out of place on the fighting-machine. Of seamanship in the old sense, very little is required. A score of sailor-men of the old type would suffice for doing duty as quartermasters and wheelmen, while the rest of the crew should be men with more or less mechanical training,—the more the better. Instead of recruiting from the fishing smacks, we should draw upon the machine-shops and locomotive-shops throughout the country, thus obtaining men to whom the handling of machinery is thoroughly familiar. This is exactly what is done in the countries of continental Europe which have compulsory military services. The young mechanics, instead of going into the army, enter the navy, where the work is congenial and similar to their own, and it gives a body of men capable of the highest efficiency. Much has been said about the versatility of the sailor of the old type, but all his training is directly opposite to what is required of the man-of-war's man on the fighting-machine.

The officers, too, need a different training from that of thirty years ago, and a beginning has already been made at our naval school towards what many believe will be the ultimate outcome, when every officer will be a trained engineer. Even now the young line officers receive considerable instruction in mechanism and practical handling of tools, and the requirements of the fighting-machine are compelling every officer who would be at home there to supplement the defects, from an engineering standpoint, of his early education. We already have the fighting-machine itself developed almost to perfection, and, with men and officers properly trained and enthusiastic about their ship, we can safely count on a future for our navy in which the brilliant record of the past will be maintained with undiminished luster.



NEW SETTLERS ON THE ROAD TO THE CRIPPLE CREEK GOLD CAMP, COLORADO.

COLORADO'S NEW GOLD-CAMPS.

By Prof. Arthur Lakes.

THE fall in the price of silver has naturally given a greater impulse to the search for gold. In the past two years gold has been found in Colorado in places where its existence was before unsuspected. One might almost think that nature had accommodated herself to the altered state of business affairs, for in some of the long-established camps we hear of veins changing from silver to gold with depth or extension. This seeming condescension on her part may be attributed mainly to the fact that, in silver-camps or silver- and gold-camps, we never hear nowadays of a silver-mine. But we do hear, without delay, from every mine that can produce a little gold. If a mine was gold-bearing as well as silver-bearing before the crash, we now hear only of its production of gold. It is a fortunate and remarkable coincidence that the ore-bodies of some mines, hitherto silver-bearing only, with extension or increased depth have passed into a gold-bearing combination. In most cases gold is found because gold alone is sought, and gold is heard from because we are interested in gold.

Since the fall in silver, and more especially since the general panic of 1893, great numbers of prospectors have been at work—either on their own account or else "grub-staked" by others—many of whom were well-to-do before the crash, but whose coffers are now depleted. Besides these professionals, with the retreating winter snows a horde of all classes and conditions has been scattered over the mountains in a happy-go-lucky kind of prospecting. Some of these are well-educated business men, who have been compelled by the hard times to shut down their business and take to the mountains as a last resort. With these are a great many of the unemployed laboring class. Probably nine-tenths of this crowd know nothing about prospecting, but it will be strange if, in a country so prolific in natural resources, they do not find something before another year is ended.

Among the various recent discoveries, the gold-field of Cripple Creek stands at present far above all others. The Cripple Creek field is not the product of that necessity which we are told is the mother of invention. It happened that, as if to forestall a coming catastrophe, the gold value of Cripple Creek was discovered nearly a year before the storm burst.

In 1891 two important camps came into existence in Colorado almost at the same time—Creede, a silver-camp, and Cripple Creek, a

THE FIRST CABIN IN CRIPPLE CREEK.

gold-camp. While Creede rapidly inspired confidence in its value and permanence by the strength of one or two of its rich silver-bearing fissure veins, Cripple Creek was slower in its advance, and business men were cautious about investing heavily in the new gold-field. Scientific men were divided on the subject of the permanence of the ore, and even of the depth of the veins; nor are we in a position even now, after more than a year's development, to be positive one way or the other. The nature of the camp is not yet absolutely proved. Few of the so-called mines which so far have produced well near the surface have, by sufficient depth or extension, attained to the dignity of what may be called "true mines," but most of them are "prospects" on a large scale. The depth of the mines in the camp rarely exceeds 200 feet, and the amount of development is rarely over 1000 feet. Few mines have penetrated to or below water-level, where important changes in the character of ores from a decomposed and free-milling character to one undecomposed, sulphid, and smelting commonly take place. Nor has the lateral extent of the ore deposits been satisfactorily shown by any one mine, though more has been done laterally than in depth. On geological grounds, and from results already attained, the most that can safely be said is that the promise of continuity of the ore-deposits and the prospects of the camp in general are favorable.

The quality of the mines might by this time have been well shown up and proved had it not been for the delay in their development by the late long-continued and unfortunate strike just at the time when confidence in the camp hung in the balance, and when gold was so

A VIEW OF CRIPPLE CREEK

PROSPECTING PARTY AT CRIPPLE CREEK.

badly needed in Colorado and throughout the country. Yet the number of shipping mines and the value of metal already shipped are remarkable for so young a camp, and speak well for its future. It is not unreasonable to expect great things from this camp now that the ban of the strike is removed, and the mines are again in operation. Hundreds of prospect holes with which the hills are speckled, as by an army of moles, are to be developed and their prospective value more nearly ascertained. Then the arrival of two competing railroads into the district will materially help, reducing the expenses of freight on the shipping ores, and causing to be profitably utilized a vast amount of low-grade ore now lying on the dump or in the reserves.

While one can count with some confidence on the permanence of a newly-discovered silver-camp, such as Creede, located on large fissure veins, after a few feet of development, one cannot as a rule depend with equal confidence upon a new gold-field, although the first few feet below the surface may be extraordinarily rich. The value of a gold prospect cannot be fairly prognosticated until the water-line, or the depth to which surface action attains, has been reached. The ores above that point are commonly oxidized, and the gold set free and able to be treated by the cheap and simple process of stamping or free milling. When this surface action "plays" out, which may be from a depth of a few inches to many feet, the ore is usually found in its unoxidized, unaltered state as a sulphid of iron or iron pyrites,—in the case of gold, with the gold shut up in its matrix of pyrite; in the case of silver, in a sulphid of lead or unoxidized galena. To extract the gold from its matrix demands a much more expensive process than

PRINCIPAL STREET IN CRIPPLE CREEK—STRIKERS LISTENING TO A HARANGUE.

PANNING GOLD AT CRIPPLE CREEK.

ordinary stamping, which may be done close to the mine,—namely, smelting or roasting, involving transportation to some place where fuel and fluxes are near at hand. Hence, while free gold in the oxidized upper portion of a vein may be milled with profit, though it runs but a few dollars, the unoxidized ore at greater depth has need to be much richer to stand the greater expense of the new treatment. As a matter of experience, the unoxidized ore proves often too poor in gold to pay, notwithstanding that the upper and oxidized part of the vein may have been phenomenally rich in free gold and gold specimens. The natural reason for this is that the upper portion of the vein represents the products of natural milling, lixiviating, etc., carried on possibly for thousands of years.

Hence the caution in not banking too quickly on the permanence of an undeveloped gold-field, and the unwisdom of erecting large and costly stamp- and other mills, on the strength of the richness of a few surface prospects. Thus at Cripple Creek, when the prospects were first opened, a good deal of the surface ore was free gold and free milling. Stamp-mills immediately swarmed, and a concern large enough to monopolize all the milling in the camp was erected by European capital. Very soon it was found that somehow these mills came only within 40 per cent. of the value attained by assays. In other words, they lost nearly half the miner's gold. It was then discovered that only a small percentage of the gold was free milling, and that mainly near the surface. With depth the gold was associated with a matrix of tellurium and was suitable, not for stamping, but for smelting. The result was that soon nearly every mine was shipping most

of its ore to the smelters at Denver or Pueblo. The stamp-mills at present treat only a small fraction of the general ore, and principally that which is low grade. Experiments of all kinds have been tried on this ore in the camp itself. The most likely one seems to be the cyanide or MacArthur process, which, after reducing the ore to fine particles, dissolves the gold in a bath of cyanide of potassium and precipitates it upon zinc shavings, and separates the gold from the silver by the ordinary cupel and roasting furnace. They claim to be able to save 91 per cent. of the gold by this treatment.

Another reason for not banking too hastily on the permanence of the camp was the peculiar geological occurrence of the veins and ores, so different from those elsewhere that a geologist could not prophesy one way or the other by comparing them with those of any other gold-mining district in the west. Some geologists thought the so-called fissure veins or zones of impregnation were "gash" veins and would be limited to the depth of the lava sheets. Others believed them to extend down into the underlying granite to an unknown but certainly great depth. The latter view is probably the correct one, for on the skirts of the volcanic area we find many veins and mineralized dikes ascending through the granite of a similar character to those in the volcanic sheets. No mine has yet penetrated deep enough in the volcanic material to absolutely prove or disprove either hypothesis. Granted that the continuity of the veins with depth is reasonably assured, it is still

SLUICING AND PANNING GOLD.

an open question whether these veins will become richer or poorer with depth. There are mines in the camp, the size and richness of whose surface ore-bodies used to be in every one's mouth, which are now with depth hunting for their ore-bodies which they are supposed to have temporarily lost. In other mines an exactly opposite state of things is the case. This uncertainty, however, is not uncommon in other mining camps of older date. In the present case, considering the age and slight development, the balance is rather favorable than otherwise.

Cripple Creek is situated near the western base of Pike's Peak, at an elevation of 9400 feet above the sea. It is about twenty miles southwest of Colorado Springs, one hundred miles from Denver, and forty-four from Pueblo. The district is characterized by smooth, rounded, rolling hills, sparsely wooded, intersected by numerous small valleys and gulches. The productive area, which is constantly being enlarged on its outskirts by fresh discoveries, is about six miles long by three miles wide and comprises about eighteen square miles. The float, or oxidized, porous, rusty rock, purple-streaked or ocher yellow, which so abundantly covers the hills, early attracted the attention of passing prospectors, but as they could locate nothing "in place" from which this float came, nothing was done in development. In the "sixties" Dr. Hayden's geological exploring parties passed over the area and scanned its geological features, but appear to have had no suspicion of its metal-bearing qualities. In 1874 a shaft was commenced in Arequa Gulch and abandoned at a point near which there are now good mines. In 1879 a tunnel was begun in Poverty Gulch which just managed to miss the ore-bodies of the present Gold King, one of the richest mines in the camp.

In February, 1891, some Colorado Springs men determined to test the district and took up several claims which promised so well that, during the following spring and summer, news having spread that there was something in Cripple Creek, many prospectors flocked in, and by the close of the year there were 2000 people scattered over the region like a pack of hounds hunting a fox. By March there were 4000 people, and by June 8000. During 1892 the progress of the camp was rapid, work being confined mainly to the location and establishment of claims, and testing their values. In the course of that year some ten or a dozen mines became regular shippers, and their output reached a total of $583,000. In 1893 the total production was $2,406,980, of which $350,000 was for the month of December alone.

Thus, in a remarkably short time after its discovery, the camp developed from prospect holes, assay and mill-run tests, into a regular producer and shipper. The main obstacles were high price for treatment, saving of values low, cost of shipment high, the peculiarities of

GREATEST STRIKE IN CRIPPLE CREEK.

[An Ore Body in Brecciated Lava, 33 feet down. Camilla Mine.]

the ore we have alluded to, and not enough development to prove permanence and warrant large investment. Added to this was the absence of railroads. It was soon found to be, in one respect, a "poor man's" camp, because pay-ore was often found at "grass-roots"; on the other hand, with depth, the ore was found to need an expensive mode of treatment.

The social condition of the camp at this time is thus sketched by a

western newspaper: "'There are psalms on the hill-side in a gospel tent, with 'hi, hi, hi! keep her going' down below; a prayer-meeting in one tent and in the next 'raising of old Ned right out by the hair.' Families, women, and children are beginning to come in. Every one comes to work for himself, and put down a hole somewhere. They come by coach and scatter over the hills. A court-house in a frame cabin is erected, and the camp boasts a justice of the peace, a constable, and other 'frills.' The consequence of this painful state of affairs is that no one is allowed to carry a gun. A shocking falling away from frontier standards and depressing to Easterners who pack in their arsenal on a mule in order to be 'properly bad.' Old-time miners shake their heads gravely and doubt if the camp will be any good because no one is killed yet."

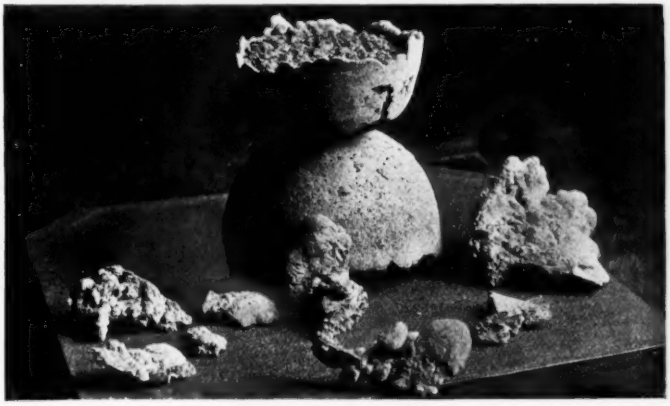
As regards the general geological features of the mining region, it is

GOLD KING MINE, AT CRIPPLE CREEK.

an oval area among the lower granitic hills at the base of Pike's Peak; covered in places to a considerable depth—probably a thousand feet or so—by volcanic lavas resting on granite, doubtless filling many an old waterworn granitic valley and submerging many a granite ridge and peak. This lava may be of two or three or more varieties, representing successive and different flows, from many different fissures and orifices. The prevailing rock is a grey volcanic *breccia*, composed of angular fragments of lava, cemented together by a lava paste. These flows appear to have been penetrated by dikes of more recent lavas ascending through fissures. These dikes and fissures are the principal ore-carriers. On the outskirts of the volcanic sheets, where erosion has removed the surface lavas and bitten deep into the under-

lying granite, we find the stumps of numerous mineralized lava dikes disclosing some of the sources of the lava flows. Still later movements appear to have taken place, opening fissures and shattering the rocks. These fissures and the crevices in the shattered rocks were filled with ore and vein matter, forming the so-called veins or impregnations. The varieties of lava have not yet been scientifically determined, but they are generally supposed to be phonolites and andesites, together with some eruptive and porphyritic granitic.

The ore-deposits for the greater part occupy lines of fracture and fissure in the lavas, or impregnate lava dikes. Some occur in fissure veins in coarse red granite, or at the junction of granite with a lava dike. The ore fills the interstices in a lava dike, or occupies a fissure in the lava sheets. Or it occurs in sandy, clayey matter on



GOLD RETORT—VALUE $7500.

either side of a dike, or it occupies the line of a fissure between more or less distinct walls, running off into every available crevice of the shattered wall rock—more often lining the faces of crevices than permeating the rock itself. In some mines there is but one vein or line of mineral impregnation; in others, two or three distinct and parallel zones or veins. The prevailing strike or direction of the veins, as well as the dikes and cleavage of the granite, is to the north and south, or a little east or west of north; the dip is usually very steep, often nearly vertical. Occasionally there are cross veins having an east and west direction. The veins are liable to be faulted, to fork and split, and to enclose "horses." In some mines the ore-body is so scattered among the crevices of the rock that none of the veins are large enough to work separately, or pay to work collectively. Large

BUENA VISTA MINE AND PIKE'S PEAK, WILSON'S CREEK.

bodies of ore have been found near the surface and developed as open quarries. With depth some of these have greatly diminished, or even temporarily played out. The ore-bodies in few mines are continuous for a great distance. They lie in patches or chutes, often with long intervals of barren rock between.

The width of the vein matter between walls may be. from a few inches to several feet, and the pay streak likewise, widening and pinching and temporarily playing out with depth or extension, to be renewed again. In some few mines the so-called vein consists of lava-clay with a remarkably regular vertical cleavage parallel to the walls. The lines of cleavage are filled with iron and manganese stains and quartz containing the ore. This vein-lava often assumes the fineness and hardness of jasper and is called jasper ore. In granite the vein may be simply a decomposed quartzose granite between walls of red granite, with seams of clay and rich sand in free gold. Again, a lava dike may occupy the space between the granite walls, and the ore lie at the contact between the lava and porphyry on one or both sides of the dike. The granite seems the most affected of the two rocks by the ore solutions which have bleached and decomposed it, leaching out some of its constituent minerals, such as mica, and replacing them with metal or with quartz, pyrite, and fluorspar. Black oxid of manganese, iron oxid, fluorspar, and quartz are commonly associated with the precious metal. The quartz is at times milky and opaque, of an opaline character; at others it forms crystalline geodes, the crystals sometimes of an amethystine color. The highest values are commonly in a soft, clayey, sandy "gouge" which, when panned, shows a large amount of bright free gold. The purple fluorspar is sometimes rich, sometimes poor, in gold. The porphyry and wall rock at times is impregnated through its mass with minute iron pyrites which does not, as a rule, carry the highest values. The gold itself may be found free, especially near the surface, associated with iron or quartz. With depth it is seldom free, or visible, but is contained in bright silvery specks of tellurium lining fractures in the rock. This telluride (popularly called sylvanite) is the main gold staple of the camp. When the tellurium is roasted, the gold appears in globules on the rock. This gold is remarkably pure with very little alloy of silver. When free it is generally rusty.

Besides the ore found in veins in the rocks, there is quite a large area that would be valuable placer ground but for the paucity of water in the district. Singularly enough, two mines struck the most powerful bodies of water we now have in the camp, in developing their veins. In one case the flow was so strong and continuous as to supply two or three mills in the gulch below. The water was so charged

with arsenic and other mineral salts as to be undrinkable. In the other case, the water which issues from the fissure vein of a mine on top of a hill was found to be quite pure. Despite the lack of water in certain localities the earth has been thrown up in mole-hills, and washed by rockers and other devices, with considerable profit, the water being brought in barrels, or else the dirt carted to distant streams and washed. The placer material consists of small, sub-angular pebbles, mixed with a "black sand" or magnetite. The gold is not much water-worn but angular. Nuggets as high in value as $33 have been found, and men have made from $1 to $5 or $10 per day.

There are in the Cripple Creek camp about thirty shipping mines, of which perhaps a dozen are dividend-paying and a few more self-supporting. The good mines are for the most part very good mines, putting out very rich ore. Others, again, are doing well, with an occasional very rich pocket. In most mines there is to be found, with the rich ore, a good percentage of medium low grade, and some very low grade. Twenty-dollar ore may be considered as medium low grade, and $10 ore as quite low grade, while $5 ore is scarcely reckoned as of any value. This depends upon whether the ore is free-milling, or a telluride and smelting ore. In the former case $5 ore would pay well, while in the latter $20 is as low as is profitable.

The high-grade ore ranges all the way from $75 up into the thousands. Some mines are steadily shipping ore worth $200. The camp at present is rated at a $100 grade, partly because that is the real average grade of many of the mines, and partly because little short of that value is at present shipped, the arrival of the railroads being awaited before the shipment of ore of lower grade. A few statistics will show the general character and value of the camp: The total output for 1893 was about as follows:

15,550 tons smelting ore valued at	$1,840,540
34,348 tons of mill ore	519,300
37 pounds of pure gold from a single mine	11,840
Placer gold	28,000
Cyanide mill product	7,500
Total	$2,407,180

The output for 1892 having been under $600,000, a gain is shown of over 300 per cent. for 1893. But for the labor troubles it was hoped and estimated that the camp would produce some $5,000,000 or more during 1894.

For the first year of the camp's history, it is said, no word of discontent was heard. Men worked nine hours, including a half-hour intermission for dinner, for $3 per day, until the arrival of bodies of Cœur d'Alene miners and professional agitators, who persuaded them

that wages ought to be $3 for an eight-hour day. The Cripple Creek miners were receiving the highest wages paid for mining in Colorado, $2.50 to $3 for ten hours' work being the average elsewhere. A large body of the miners having been persuaded to join the miners' union, they became aggressive, refused to work, prevented others from working, and attempted to dictate to mine-owners. The owners, for the most part, declined to be dictated to, and shut down their mines, and the feeling grew bitter on both sides. The union men having the upper hand, the rest had to submit under intimidation, with the result of paralyzing business. It was felt that a crisis was impending and it began to come toward the last of May, when the new railroad, having reached the outskirt town of Victor, brought one hundred well-armed deputies. Their arrival was the signal to the strikers to blow up one of the mines with dynamite. The miners had fortified the hills in every direction, and were well organized and well armed, so that the handfull of deputies would have been powerless to cope with them. The latter, therefore, retired to await reinforcements. A slight skirmish occurred between the deputies and a body of miners, in which two men were killed and several wounded. In June, after demonstrations in force by deputy sheriffs and the militia, a compromise was effected and most of the mines were reopened.

The effect of the strike was for the time being a paralysis of business. Several mines which had been operated on lease, however, were not interfered with by the strikers. Besides many prospects are being developed, some of which doubtless are to become important mines of the future. Despite the strike, the size of the town has nearly doubled since last year. The population in the district now numbers about 10,000. The streets are crowded nightly with employed and unemployed and by a throng of loafers, both professional and enforced. The worst feature of a strike of this kind is not so much in the loss of money and time, as in enforced and long-protracted idleness. One who sees hundreds of men loafing outside the saloons with blear eyes and dilapidated frames, and a general slouchy air, wonders that they could ever have been or could again become industrious, active, bright-eyed miners. It is impossible to walk through a camp in this condition without feeling its depressing atmosphere.

Most of the other new gold-camps in Colorado are so infantile that little can be said of them or of their future. Some of the old camps have become rejuvenated and freshly gilded, and are doing better than they were. Some, generally considered as purely silver camps, have accommodatingly found gold. Not a stream that flows from the great ranges but will pan and show some "color."

The Leadville gold-belt, recently discovered, was credited last November with producing at the rate of $2,000,000 a year. Gilpin county in 1893 produced upwards of $2,000,000; Clear Creek county produced $300,000; Summit, $1,000,000, and Boulder and San Juan about the same. In Park county old workings, both on veins and on placers, have been reopened with profit. In Gunnison county promising gold discoveries have been made on Goose creek and Ohio creek. Silver Cliff, in Custer county, has also swelled the "golden tide." At Creede some of the silver-mines with depth have shown gold. Some fifty small camps have been opened up in twenty counties.

At Leadville the gold-belt passes through Breece hill and Idaho Park and along the Mosquito range for some miles in a general north-and-south direction. The Leadville region is one of porphyry and limestone. At the contact of these rocks, the lead-silver ores have hitherto been found. In somewhat similar contacts gold is now found, associated with silver, also between two porphyries and in fissure veins and impregnations of the porphyries. At Goose creek, Gunnison county, veins occur in a volcanic *breccia* and in granite. The gold is free-milling and is also associated with copper and iron pyrites. On Ohio creek placers are tunneled down to bed-rock, yielding at times from $15 to $30 per ton. In the La Plata mountains, in southwestern Colorado, large placers have been found, panning, it is said, from 50 cents to $1 per pan. These placers have been traced to gold-veins in place on the hillside, the ore of which was low grade but plentiful. In Park county, on Crooked creek, rich gold float has been found.

From the top of Mount Pizgah, a very prominent peak above the town of Cripple Creek, one looks west over a low rolling country composed of lavas and granite, covering many square miles and extending southward to the Arkansas-river cañon and northward to the southern end of the basin of South Park. This volcanic region, after his experience with Cripple Creek, is highly suggestive to the prospector as a likely one. Towards its northwestern limit a small camp called Balfour has been opened on the strength of a few prospect holes, showing moderate assays, and a general mineralized character of the eruptive rock as at Cripple Creek. This may or may not prove, with development, to be a sister of Cripple Creek.

Colorado has no little "grit" in the make-up of its citizens. Driven out at one point, they are up and at it again at another. At one time Colorado was an important cattle-raising state. This business failed, and it became a silver state. This, too, has temporarily failed. Attention was turned to its great coal-fields, clays, building stones, and baser metals, and now it is not improbable that ere long it will be widely known as a gold-producing state.

THE EARLY LIFE OF GREAT INVENTORS.

By Leicester Allen, A. B., M. E.

DIFFERENCES in mental traits as well as differences in disposition manifest themselves very early in life. Two boys playing together will expose the intellectual predilections which are to guide them in the selection of their calling, and influence them through all their future years. One, perhaps, seated studiously in a corner, or on the bank of some mill-pond, will try to fashion a boat out of a shingle or a piece of board, shaping the outline in accordance with the outline of any ship's deck that he may have seen, and providing it with a mast, rudder, bowsprit, and paper sails. But a companion will approach and offer to trade pocket-knives, not intentionally interfering with the pursuits of industry, but giving expression to his strongest propensity. The young shipwright has strongly developed faculties of construction, and may possibly become an inventor in after years. Or he may become a manufacturer merely, availing himself of the inventions of other men and turning them into the channels of profit. But that his companion will become a merchant or trader of some kind will be too probable to need suggesting.

It is a common impression that young men select their callings with a view to the profits that may be gained, and that they become merchants, manufacturers, or professional men with definite ideas in relation to the pecuniary rewards that may follow upon success. But, except in rare cases, it is probable that this is not a true impression. We know that an overwhelming majority of young men choose callings in which there can be no reasonable expectation of fortune, and often they never afterwards cease trying to kick themselves for their thoughtless blunder. Men discover very early in life the need for labor of some kind; but they are much more likely to select the kind that seems to be congenial to their taste, or more promising to their ambition, than the kind that promises the largest pecuniary rewards. It is doubtful, indeed, if the desire to accumulate wealth is strong enough in any young man just starting in life to give him his direction. A few young men will be heard to say that there is not money enough in this or that occupation to lead them to follow it, but even in such cases it is generally true that lack of predilection rather than very clear eyes looking to results lies at the bottom of their decision. The desire for accumulation comes at a later period, after the romantic ideas of life which possess most young men have given way

to the reality, and they have learned to see that the measure of their pecuniary success is generally regarded as the measure of their ability. It is even doubtful if young men ever select a calling with a view to getting rich. Many young men are led into their pursuits by their environment, their adaptability, springing only from hereditary traits at best, and manifesting not even hereditary fitness. These accidents result in placing many square pins in round holes, and many round pins in square holes, but they are only accidents, and, as a rule, the choice of pursuit is inspired by mental organization. What manner of men, then, are the men who become great inventors, and contribute more than any other men to the visible progress of society?

In this field of research we find that the profession of painting has contributed a larger proportional number of the great inventors of the current era than any other pursuit. Notwithstanding the comparatively small number of professional painters extant, we find, indeed, that they have contributed, either directly or indirectly, nearly all the inventions that have given distinctive features to modern civilization. Robert Fulton, the first person to make a commercial success of the various devices for steam navigation that had been conceived, was a portrait-painter, and, as the frontispiece to Webster's "Unabridged Dictionary" testifies, a very good one, too. But his invention not only covered the oceans, rivers, and lakes with steam-vessels, but it suggested the locomotive, and covered the continents with railways. Morse, the inventor, who sent the first telegraphic message over a long line of wire, was a landscape-painter, and was elected and reëlected president of the National Academy of Design during the entire twenty years while he was incubating his idea, mainly to strengthen his resources. But Morse, again, was the parent of still other inventions. The telephone is the direct offspring of the telegraph, and even the electric light, when we consider its appliances for distribution, seems remarkably like a first cousin. Daguerre, the magician who set the sun at work as a journeyman and opened the way for all the refinements of photography, was another landscape-painter, and the man who contributed so much to the pictorial resources of this Magazine by compelling the great luminary to work on metallic sun faces in photo-lithography was still a fourth man among the painters who have been making a mechanical and almost a social revolution. We see, therefore, that there seems to be a very intimate relation between invention and the fine arts.

A peculiar illustration of the way inventors are made is furnished in the life of Eli Whitney, the inventor of the cotton-gin, a man whom Macaulay classified with Peter the Great as an architect of the prosperity of great nations. Whitney was a nail-maker during the

revolutionary war, shaping the nails by a hand process; but he was ambitious, and finally got together money enough to enable him to matriculate at Yale. After he was graduated, he went south to fill a place of tutor in a private family. But, finding the position filled, he determined to study law, a decision that would have resulted in placing a round pin in a square hole had he not received a better direction by accident. His constructive faculty had not escaped the observation of a lady in whose house he had been invited to make a home while studying law; and when some visitors were heard to express regret that a better means than hand labor could not be found for ginning cotton, she directed them to Whitney with the assurance that he "could make anything." The result was the cotton-gin, and the conversion of a prospectively commonplace lawyer into a great inventor. But by this invention Whitney realized no share of the great national wealth that he created. Defrauded of the profits of his invention, he was obliged to engage in the manufacture of arms as a means of obtaining fortune that was his due, and his life, therefore, illustrates the adverse fate that often follows the inventor as well as the circumstances by which he is made.

Allusion has been made to a quality of mind that must be possessed alike by artists and inventors, since so many painters have also been inventors. It has also been said that poets are born, not made. The power of imaging in the mind things not present to sense is this common quality shared by painters, poets and inventors, and the great writers of romance as well. When we look for something in the youthful training of inventors for the influence that has given direction to their life-work we shall mostly fail to find what we seek. From the unlearned (that is to say, those who have not received the systematic education afforded in schools), have come the largest number of adepts in invention; but this class has in all ages far outnumbered the scholarly class. In examples soon to be cited as a fair average of early training received by those who have revolutionized arts and industries by invention, some have received collegiate or university education and others have had only the most meager opportunities and gained only the mere rudiments of education from schools. But all have been imaginative, studious men, self-educated to expertness on the lines whither their genius led them, and all possessed that untiring persistence that never yields to temporary discouragements.

Let us begin to draw our examples of such men from the history of the art of printing—the art preservative of all arts—and then, without standing upon our order of going, ramble abroad over the field of invention, to see what start in life some of the boys who, as men, revolutionized industries, arts, and sciences, were able to get.

The names of Andrew Campbell, William A. Bullock, and Richard M. Hoe are inseparably connected with the progress of the art of printing. Each of these men sprung from obscure positions, and each achieved much. Campbell, left an orphan at the age of twelve, worked afterward on a farm; but his genius led him to mechanical pursuits and, finally, to the invention and manufacture of high-class printing-machines. His ingenuity was no greater than his personal force and decision of character. He once cabled an entire patent specification to English patent agents at a cost of a dollar a word in gold, in order to head off a workman who had started on a steamer for England with a view to anticipate an invention considered valuable, and which the then existing patent law of England permitted the first applicant to obtain. Bullock began life as an iron-founder and machinist, manufacturing hay- and cotton-presses. From these comparatively rude machines it was a long step to his famous printing-press which delivered 30,000 sheets per hour printed on both sides; but he was equal to that achievement, the effect of which upon the publication and distribution of news was scarcely inferior to that of Edison's improvements in telegraphy. Hoe was the son of an English farmer and started as a boy to learn the trade of joinery. Coming to America, he worked at his trade a little while, and then joined his brother-in-law in the manufacture of a hand printing-press invented by the latter. From this small beginning sprang the great establishment afterward carried on by Mr. Hoe for the manufacture of the mammoth power printing-presses now so extensively used in the great newspaper-offices, and from which sheets are thrown out printed on both sides at a rate almost incredible to those who have not witnessed the operation.

Sir Richard Arkwright, born in poverty at Preston, England, worked from boyhood as a barber and shaved faces until he reached the age of thirty-five, at which period he began to astound the civilized world by a rapid succession of inventions that completely revolutionized the manufacture of textiles. From the introduction of his machines dates an era in the industrial arts. An example of a different character is furnished in the career of Professor Alexander Dallas Bache, a great-grandson of one of the greatest Americans, Benjamin Franklin. Unlike his renowned ancester, Professor Bache had excellent educational advantages. Graduating at the age of nineteen at the head of his class at the West Point Military Academy, he was retained there as professor, and, at the age of thirty, was chosen president of Girard College. Subsequently given charge of the United States coast survey, his improvements in instruments and exactness of methods gained him world-wide fame. He was not only an able scientist; his fame as such has overshadowed the fact that he was also an accomplished engineer and inven-

tor. Another man of rare genius of whom the public has known much less than of Professor Bache, was Simeon Borden. This inventor and engineer was emphatically a self-made man. After receiving such instruction as was afforded by a district school in his native place (Fall River, Massachusetts, then called Freetown), he mastered the arts of working in wood and metals and the studies of geometry and applied mathematics without other assistance, and qualified himself as a skillful surveyor and mechanician. He performed the first geodetic survey ever executed in America, and its accuracy was confirmed by the subsequent work of the United States coast survey under Professor Bache. He was numbered among the earlier railway constructors, and his life well illustrates what a man with health, determinate purpose, and untiring perseverance can accomplish. He also surveyed and marked the boundary-line between Massachusetts and Rhode Island, which had been previously a subject of much dispute.

Another engineer who made the world respect his talents was James Brindley. Son of a poor and dissolute father, through his own efforts he struggled to the front, and demonstrated that he could drain mines, build mills, and construct canals for internal navigation, becoming, in the latter capacity, famous as a constructing engineer. Issuing from the grime of a coal-mine a poor fireman, rude in manners, uncouth in person, entirely self-taught, George Stephenson gave to the world one of its most wonderful machines—the locomotive. Others who had been privileged with immensely greater advantages—one of them no less than the great John Ericsson—strove to wrest the prize of this achievement from the grasp of the daring innovator; but it remained for history to record that, of all the machines brought forward, his and his only became the parent and progenitor of the modern locomotive. Who shall estimate the effect of this great invention upon the progress of the human race? A son (Robert Stephenson) of the great inventor of the locomotive received an excellent university education and became a famous civil engineer, particularly noted as a constructor of famous bridges. Honor after honor was conferred upon him at home and abroad; yet all these pale in the splendor of the renown which will forever perpetuate the name of George Stephenson.

The invention of the tubular boiler, without which not even Stephenson could have succeeded in making a practical locomotive, is proved by indisputable evidence to be due to Nathan Read, a native of Warren, Worcester county, Massachusetts. Read was educated in Harvard University, directing his attention first toward theology, and afterward toward medicine. After leaving the university he became an apothecary; then he engaged in the manufacture of chain-cables, anchors, etc., in the Salem iron-factory, of which he was one of the

founders. He made several inventions, but the most important, the tubular boiler, was not generally adopted until a subsequent period, thus sharing the fate of many inventions that have appeared before the time was ripe for their introduction.

Ephraim Ball, inventor of the "Buckeye" mower and reaper, and the "American" harvester, and other agricultural machinery, began his career at fifteen as a jobbing carpenter's apprentice in Canton, Ohio. He lived to see the great revolution in agricultural operations following the general use of this class of machinery. His early education was extremely meager. Thomas Alvah Edison was launched into the active business of life at the age of twelve as a newsboy on a railway-train. His early education was received from his mother, who was a teacher. Now his name is a household word in all lands as that of one of the greatest inventors this century has produced. Erastus Brigham Bigelow, than whom no American has contributed more (if any as much) to the art of weaving, was the son of a cotton-weaver of West Boylston, Massachusetts. The failure of his father in business curtailed his educational advantages, yet he became singularly prolific and successful in invention and in business, and evinced some skill as a writer upon economic subjects. Smeaton, the foremost civil engineer of his generation, and also a noted inventor, was principally self-educated. He gave evidence at the age of fifteen of rare mechanical ability, subsequently fulfilling his early promise in this regard by numerous improvements in mill-work. Afterward, turning attention to civil engineering, he erected on the site of repeated failures the famous Eddystone lighthouse,—a grander monument of his skill and genius than any sculptor could chisel.

James Watt, the father of steam engineering, was in youth a maker of philosophical instruments; and it was in this capacity that he began his studies of the nature of steam that have crowned his name with honor both as scientist and mechanician. Eli Whitney Blake, inventor of the celebrated stone- and ore-crusher that bears his name, was a graduate of Yale, intending to pursue the legal profession. His uncle Eli Whitney (inventor of the cotton-gin), seduced him from this line of study to give aid in organizing the Whitneyville gun-factory. Here Mr. Blake made important improvements in gun-making machinery, but he will be remembered principally from his invention of the stone-crusher. He was also a forcible writer upon scientific subjects. Jacob Perkins, noted as the inventor of the first practical machine for the manufacture of cut nails and for his improvements in coining and bank-note engraving, was in youth a goldsmith's apprentice. Thomas Blanchard, inventor of machines for making tacks and machines for turning irregular forms such as gun-stocks, shoe-lasts, etc., metamorphosing the trades in

which these articles were produced, was brought up as a hand tack-maker. William D. Andrews, inventor of the centrifugal pump so much used in raising sunken vessels and saving cargoes, graduated into engineering and mechanics from a New England country store. He has added many other inventions, the latest and most important being his system of gang tube-wells for supplying water to cities and towns. The brothers J. and W. Hyatt, inventors and introducers of celluloid, were printers before they made their debut as inventors. Corliss, of "Corliss engine" fame, was the son of a country physician, and was educated in the Greenwich (N. Y.) Academy. Alexander Graham Bell, whose name is identified with the telephone, was the son of an Edinburgh teacher of deaf-mutes. He had fine educational opportunities in the Edinburgh University and is renowned not only as an inventor but as scientist.

But it would be superfluous to further extend this list of examples to inclusiveness, and it would be impossible to do so in a magazine article. Were it attempted to include also the names of scientists as well as inventors who have risen from obscurity and even from poverty, surmounting repeated obstacles till their names were written on the glittering scroll of fame, we should find in this list the honored names of Benjamin Franklin, Joseph Henry, Michael Faraday, and a host of others who had not the aid of fortune to help them on their way. And the list would reach back to remote ages that produced an Aristotle, an Archimedes, a Hero, a Euclid.

Enough has been said to prove that inventors are not made by commercial requirements for invention, by education, or the possession of wealth. Any or all of these conditions may exercise either a favorable or an adverse influence, depending upon individual character. And though

> "Full many a flower is born to blush unseen,"

and all inventors do not become great and famous, it is yet as true that inventors are born, not made, as it is of poets and artists. This does not imply that inventors may trust alone to blind inspiration, any more than may poets or artists. Improvement and development of any talent comes only by hard work, whether in school, atelier, library, or laboratory; and all who have achieved anything worth speaking of in this world, have possessed that ability and willingness to work which is the very soul of genius.

THE PREVAILING JEALOUSY OF WEALTH.

By William Nelson Black.

IS this merely a social question suitable only for the contemplation of ideologists, and men who have leisure for the examination of social problems? It involves some very threatening possibilities. The civil or electrical engineer, for example, engaged on some large work undertaken by a man of wealth for purposes of gain, would not think it an irrelevant question among practical men were he invited to an interview some day, and told that a recent rise in stocks, or some unexpectedly fortunate speculation, had brought the fortune of his employer up to the legal limit of accumulation, and that all his employés must be discharged.

But there is no legal limit to accumulation, it may be said. You are supposing an impossible case—setting up a man of straw, in fact—in order to knock him down and show yourself a sociological athlete. This objection would seem to have some force. There is no legal limit to accumulation to-day, but how will it be to-morrow? Do we not hear upon every side, not alone among tramps and men who may be regarded as altogether unsuccessful in the accumulation of wealth, but among men of considerable substance, mutterings about the danger that threatens the community from men of large fortunes? Congressmen who would pass an income-tax law when it is not needed, for the mere purpose of despoiling men of wealth, have not very far to go to begin advocating the confiscation to the State of all incomes that rise above the standard fixed for purposes of taxation. Taxation is the favorite expedient of men who mean confiscation.

The jealousy of wealth will furnish an intensely practical subject for reflection so long as the politician maintains his present importance, and the most ignorant members of the community can control his conduct in their own behalf. We have many laws upon the statute-books through which capital has been hampered in its operations merely for the gratification of the jealousy which is so prevalent at this time; and the chief study of a very large proportion of the men who seek office is to find measures for crippling the capitalist. The precise relations of the man of wealth to the community should be more frequently considered, in order that the men who are willing to serve as breakwaters against ignorance may see its floods diminished as much as possible in volume, and made less irresistible in their flow.

What is the meaning of the words when we speak of the accumu-

lation of wealth? As the process is commonly understood, to accumulate is to gather together something already existing; and hence the popular impression that men get their wealth by taking something out of the hands of other men and appropriating it to their own uses. There could hardly be a greater misconception. The accumulation of wealth by all the honest processes of production, or by buying and selling, is really the *creation* of wealth; the production of something that would absolutely have had no being had it not been for the personal exertions of its creator. Yet this fact is only dimly comprehended by most men who bother their heads with social problems. Sometimes it is not comprehended at all. Men seem to go upon the assumption that there is just so much wealth in the world, and that life is a struggle to see who shall make the largest grab. But as a matter of fact the fortune of every man who earns money by lawful means is simply his part contributed to the total of the national or social wealth.

Take the career of George M. Pullman, just now a conspicuous target for the abuse of addle-headed labor leaders and Populist cranks and "reformers." Starting as a poor boy, through sheer force of inventive genius and masterful business capacity he has amassed an enormous fortune. But every dollar represents new wealth, and no man has ever dared to cast a suspicion upon the character or methods of the man. In fact, William T. Stead, the sensational English editor and reformer, who lately had so much to say in favor of the poor and against the rich and the corrupt elements of Chicago society, when it came to Mr. Pullman found it necessary to say this:

> The first Pullman car which he constructed and put on the rails cost $18,000 to build, as against $4000, which was the price of the ordinary sleeper. Railway-men shrugged their shoulders. It was magnificent, they said, but it was not business. A palace sleeping-car at $18,000 could not possibly pay. Mr. Pullman refused to be discouraged. "Let the traveling public decide," was all he asked; "run your old sleepers and the new ones together; I will charge half a dollar more for a berth in the Pullman and see which holds the field." The verdict of the public was instant and decisive; every one preferred the Pullman at the extra price, and the success of the inventive car-builder was assured. He has gone on step by step, from car to car, until at the present moment he is said to have a fleet, as he calls it, of nearly 2000 sleepers, which are operated by the Pullman Company. They have besides 58 dining-cars and 650 buffet-cars. Altogether the cars which the company operates number 2573. Other competitors have come into the field, but Mr. Pullman deserves the distinction of having placed every railway traveler under an obligation by acting as pioneer of commodious, luxurious, and safe railway traveling.
>
> After building his cars in various parts, Mr. Pullman decided finally to centralize in the center of the American continent. Carrying out his decision, he naturally fixed upon Chicago as the site for his works. The Pullman Company was incorporated with a capital of $30,000,000, the quotation for which in the market to-day is twice that amount. He took up an estate of over three thousand acres round Lake Calumet, which is fourteen miles from the center of Chicago, and which was at that time far out-

side the city limits. There, following the example of Messrs. Krupp at Essen, he set to work to construct a model city in his own image. The car-works were, of course, the center and nucleus of all. In these gigantic factories, where 14,000 employés work up 50,000,000 feet of lumber every year, and 85,000 tons of iron, they have a productive capacity of 100 miles of cars per annum. Their annual output, when they are working at full stretch, is 12,500 freight-cars, 313 sleeping-cars, 626 passenger-cars and 939 street-cars.

Now all this enormous accumulation, representing millions in value, affording profitable employment to thousands of people, and conferring grateful comfort upon millions of travelers—all this had no existence when Mr. Pullman began, and it has all been created under his immediate personal direction. To say that his employés did it, or that it would have been done by some one else, is equivalent to saying that Napoleon was not necessary to his work, or that electricity would have reached its present practical development without the aid of Morse and Edison and Bell!

Or take the case of Jay Gould. This much-abused millionaire left a fortune estimated at $70,000,000, the product of a life of great activity in planning and executing works of public utility which continuously employed whole armies of men. But will any man doubt that he contributed the full total of $70,000,000 to the national wealth? Will any man doubt, indeed, that he contributed several times the amount of his own fortune to the total? Consider the wilderness reclaimed, the new towns that have grown into importance along his lines of railway, with their increase in the values of real estate, the manufactures promoted, the contractors enriched, and the various other incidental profits that follow upon the prosecution of great works. Were it said that Jay Gould contributed $500,000,000 to the national wealth during the forty years of his active career the estimate would not be excessive.

What is said of Jay Gould could be said in different terms of Commodore Vanderbilt, whose fortune, now enlarged in the hands of his family, causes so much jealousy. He contributed to the total of wealth vastly more than he secured for himself, and it is reasonable to presume, much more than his entire family of the third generation now holds in its possession. So with many other men of his kind, and in this field of research examples crowd upon us. The Bell Telephone Company, the electric-light companies, and the electric-railway companies, are all very recent representatives of a wealth that would have been non-existent but for the inventive talents and enterprise of their promoters. But even here, too, we must make large estimates for an incidental increase in values. The electric railways are penetrating the suburbs of all our large cities, and by making them more accessible they are adding incalculably to suburban wealth. Yet not a dollar is

taken from the public for which an equivalent is not given, either in the form of greater convenience or in actual profits.

Can it be said that these examples are not comprehensive enough to cover the general processes followed in the accumulation of wealth? He would be a man very defective in his powers of observation and analysis who would assert that he could discover any fundamental difference between the operations of the man engaged in railway-building, for example, and the operations of men engaged elsewhere in creating wealth. Wealth is not so objective in some forms as in others, and the processes of creation are more subtile in some fields of economic activity than in others; but the banker, the merchant, the manufacturer, the railway-builder, the contractor, and even that most distrusted of all operators, the speculator, are all subject to a general law of accumulation from which they cannot escape. Even those who seem to work least themselves are yet forced to help keep in motion the machinery of industry, and the result is the creation of new wealth. Except either by inheritance, to which it would be silly to object, or by transactions which, in the evolution of jurisprudence, make candidates for the penitentiary, no man gets possession of more wealth than he creates, and no man can create wealth without contributing to the wealth or income of many other men whom his operations concern. The right, then, of a man to possess all the wealth that he can lawfully obtain cannot be successfully assailed by even the most coherent of the followers of the philosopher who taught that all "property is robbery."

Find the community where there are the fewest beggars, and you will always find the community where the race for fortune is most precipitate. Will there be anything anomalous in this discovery? The mysterious disappearance of the beggar can be easily understood. You have only found the community where labor is most in demand; for the law, which prohibits the acquisition of riches *except through the employment of labor*, is here in full force; and hence the man who would be forced into beggary elsewhere is here enabled to become an honest, industrious, and thrifty citizen. Liverpool, in England, we are told, is swarming with beggars. Apologists for Liverpool will say that this is true only because Liverpool is a seaport town. But other seaport towns are not troubled with a plethora of beggars. The cause of the difference is right here; Liverpool is the one city in the world where disguised but practical socialism is rampant, and where the battle of life seems to have been abandoned; or, if not abandoned, where the retreat from the field is most demoralized and disastrous. From Liverpool we hear of municipal docks, municipal warehouses, municipal railways, municipal tenement-houses, and heaven knows what not of municipal

humbuggery. The Liverpool capitalist seems to have gone to Manchester or retired; and there is nothing left for a beggar to do but to beg. By the time New York comes to her municipal railway she may have as many beggars as Liverpool. It is to be hoped that no member of the New York Chamber of Commerce will be found in their ranks. But the future is uncertain.

The most benevolent institution in the world is the factory that employs one thousand men, unless it is excelled in its benevolent features by the factory that employs two thousand. In the view of benevolent intentions, however, one factory will be just as good as the other, because the proprietor of the smaller factory, if impelled by the proper spirit, will intend to make his employés number two thousand as soon as he can find a market for the work of so many hands.

But the argument from benevolence, like the argument on the title to possession, is so evidently on the side of the man who is endeavoring to get rich that there can be little need for further elaboration. Let us dismiss the benevolent features of money getting, then, and consider such further suggestions as the subject raises, including the suggestion of danger.

If it is both right and benevolent for a man to get as rich as he can, is it not the duty of society, in its own interest, to encourage the pursuit of wealth instead of throwing obstacles in the way? We may be told that there will be no need. The lust for riches is so great that we can always expect an excess of money-getters. This may be true except in the suggestion of excess; but it is easy to check the growth of accumulation by pandering to that ignorant sentiment that leads to industrial disorders. A strike in a large factory may involve the sacrifice of millions of dollars, and who can say how many of the strikes, which for several years past have been plaguing the country in all its industries, have been due rather to misconceptions of the nature and mission of wealth than to inevitable differences over terms between workmen and their employés, the ostensible reason for strikes. Many labor leaders are sensible men; but many, also, are influenced by cranks; and still others are cranks in their own right who cannot be trusted to direct the forces under their control along sensible lines. It will be safe to assume that several hundred millions of dollars are sacrificed by the country each year because a few fools think in their hearts —the only place where they are capable of thinking—that "property is robbery" and that all rich men are robbers.

But all this does not meet the question of danger to the community, a danger which is supposed to threaten from the possession of great wealth concentrated in the hands of a few men. No, for there is no such danger to be discovered by men who take unemotional views of

our social environment. In the first place, it is a great error to suppose that wealth is concentrating in the hands of a few men. In 1850, the wealth of the country was something more than $300 per capita. In 1860 it exceeded $500; in 1870 it had risen to more than $700; in 1880 it was over $900; and in the census of 1890 it is reported at over $1000. It should have been more than $1100 by the last census had the preceding ratio of increase been sustained; but strikes having been unusually frequent during the last decade, they have done their work in checking the production of wealth, and we must knock off $100 a head from the total of the national wealth that might have been reached. But an increase from $300 to $1000 in fifty years is remarkable, and it shows that the circle of rich men is continually enlarging relatively to the mass of the community. But the figures may be made to demonstrate it in another way. Were the wealth of which Jay Gould died possessed distributed per capita among the people of the United States, it would give about $1 to each person. Then what a great number of large and considerable fortunes it would take to make up the total increase of $700 per capita in fifty years.

As a matter of fact, the circle of rich men is not only rapidly increasing in numbers, but as it increases the very rich are falling instead of rising in their proportional weight to the community at large. Commodore Vanderbilt could and did turn St. John's Park into a freight station many years ago; but the whole Vanderbilt family could not do a trick of the kind to-day. Their failure, however, would not be due to the fact that the people, as the word is popularly used, have become more influential in the government of the city of New York. It would be due to the fact that there are more men of wealth. It takes the capitalist to fight the capitalist: both like it; and danger only threatens when, like the New York Chamber of Commerce in its recent bout with the elevated railways, they invite the politician to umpire the match. But even were we not protected by the conflicting interests of capital itself, there would be little cause for alarm. Wealth is always on the defensive: and our chief sense of danger is derived from the scarecrows erected by men who are at once jealous, discontented, lazy, and incompetent in the pursuit of wealth.

Instead of being a source of danger, wealth is very dependent and impotent in certain of its relations to the community. The experience of Andrew Carnegie furnishes a case in point. It was only recently that the factory of this great industrial operator, at Homestead, the fruit of a lifetime of intelligently-directed effort, was struck down by his employés: and it took a brigade of soldiers to rehabilitate it and enable him to fill his contracts. Yet his entire fortune that had not been given away for really less benevolent purposes than his in-

dustry represented, was invested in this and neighboring factories, and he suddenly became a poor man so far as the productive resources of his wealth was concerned.

So the richest men are rather employers and administrators than proprietors according to the commonly-accepted meaning of the term. They are managing their fortunes for the emolument of men who, through the combined forces of combination and competition, manage to obtain at least 90 per cent. of the product. It has been often said that no matter how rich a man may be he can draw nothing from his fortune except his food and clothing. Granting that his mental appetites and tastes need food for their indulgence, the saying is quite true. No man can draw more from his wealth than sufficient for the personal needs of himself and family: and all the rest belongs to the community, not in the comprehensive sense in which the State Socialist or burglar might claim it, but in the true sense. The first thing that every man is forced to do when he sets out to make a fortune is to employ somebody to help him: and the more ambitious he gets the larger and larger becomes the number of his assistants. Some are directly engaged in the promotion of his plans, and draw their compensation directly from his pay-rolls: but by far the larger number are indirectly engaged, and remain invisible to all except the economic analyst. The wholesale merchant, for example, seems to employ only a few quill-drivers and truckmen: but his employés are sometimes scattered all over the world, and it is due to his thirst for wealth, and the thirst of other men in kindred pursuits, that these distant employés can find a market for their labor. It will be seen, therefore, that no man can pursue wealth exclusively in his own interest, however selfish he may be: and when one sees how little there is beyond the reach of men of modest but competent income that the man of large fortune can enjoy, he is led to wonder sometimes at the assiduity of the pursuit. But habit has a great deal to do with it, and the needs and aspirations of a family impel the richest man to further exertion. In this country men rarely retire from business until they die, and it is fortunate for the community that this is true.

It has not been the purpose here to write a panegyric on money-making, however the reasoning may sound to persons who possess their souls in conscious superiority to all such sordid motives. Many men do not pursue fortune as the chief end of life, and prefer to follow callings that directly gratify their intellectual sympathies or tastes. Others, again, who seek money as a first inducement, compromise with their sympathies and select pursuits from which one of the colossal fortunes of the world cannot be expected. But these are examples which cast no reflection on the men who wish to become as rich as

Vanderbilt, or richer. From the material point of view these men are the most useful members of the community, and the man is either a public enemy, a fool, or both, who seeks to obstruct their operations. The writer could not write, the painter could not paint, and the laborer would literally be forced to go fishing were it not for the forces which the wealth-seekers put in operation. The very genius of progress, under the free institutions that we enjoy, rests upon the principle of great rewards to those who accomplish great works; and whatever else may be wrong in our social and economic system, we can not afford to discourage, much less dispense with, the great "captains of industry" who marshal the forces of labor and lead us on toward the golden age that will see the race emancipated from poverty.

VIEW OF THE OLD ILLINOIS AND MICHIGAN CANAL.

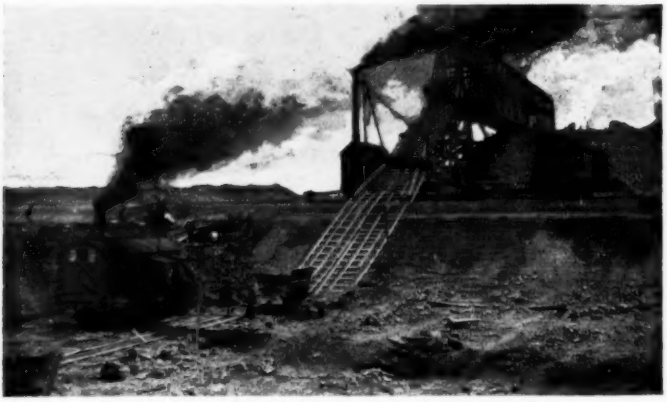
THE CHICAGO DRAINAGE CHANNEL AND WATERWAY.

By G. P. Brown.

ANY work which Chicago may undertake for a long time to come must have more than ordinary proportions not to be dwarfed by comparison with the stupendous and artistic creation at Jackson Park. But before the completion of the World's Fair buildings the city had made a beginning of another work which, at any other time, would have attracted universal attention.

Chicago has long been troubled by a contamination of its water-supply, due to an irrational method of disposing of its sewage. The water-supply obtained from Lake Michigan, in its natural state, is as wholesome as that of any other large city in the world. Indeed, it is claimed for the unpolluted lake-water that it surpasses in purity that of all other large supplies. When Chicago's sewerage system was planned there was no apprehension of evil effects from discharging the sewage into the lake. But the city grew more rapidly than its founders anticipated and sewage and water-supply soon mingled. Temporary relief was obtained from time to time by extending the supply-tunnels farther out under the lake, the last tunnel constructed being four miles long, but in spite of these extensions sewage often reached the inlets, and epidemics of disease resulted.

For a long time different plans were discussed for the disposal of the sewage or the introduction of water from other sources. Pumps were constructed at the head of the Illinois and Michigan canal and much of the sewage was lifted into this canal and sent down the valleys of the Desplaines and Illinois rivers. But the canal and the pumps were inadequate to the necessities of the case. Besides, the people living in the valleys objected very justly to having undiluted, or imperfectly diluted, sewage flow past their very doors. Years of discussion and investigation have led at last to the adoption of a plan which involves the partial restoration of a former outlet of Lake Michigan and which, it is hoped, will give Chicago a thoroughly satisfactory means for the disposal of its sewage. This new channel, now in process of construction, will extend from the south branch of the Chicago river to Lake Joliet, a distance of thirty-six miles. It will be cut so deep that the current of the Chicago river will be turned backward, and, with the sewage which it will discharge into the channel, there will be an abundant supply of pure water from the lake. It is as-



ONE OF THE METHODS OF EXCAVATING EARTH.

sumed that the sewage, by reason of the large dilution, will be rendered innocuous before it reaches Joliet. At that point it will be discharged into the Desplaines river, which, by its confluence with the Kankakee a few miles below Joliet, forms the Illinois, the latter emptying into the Mississippi.

More is contemplated than the construction of a mere sewage-outlet. In fact, the people living in the interior of Illinois state would not consent to the construction of a drainage channel until Chicago agreed to build one that would also be serviceable as a waterway. The double object of adequate dilution of the sewage and of navigation was thus secured. To fit the channel for its double object, the narrowest part is to be 160 feet wide and the depth throughout sufficient for the passage of vessels drawing not less than eighteen feet of water. For a distance of about twelve miles the cutting is through solid rock. The walls here are perpendicular and the depth from the surface of the earth from thirty to thirty-five feet. The channel will pass not less than 600,000 cubic feet of water per minute at a velocity not exceeding three miles an hour. The greater part of the proposed work is in the hands of contractors, with the stipulation that it shall be completed in 1896. The total cost has been estimated at $25,000,000.

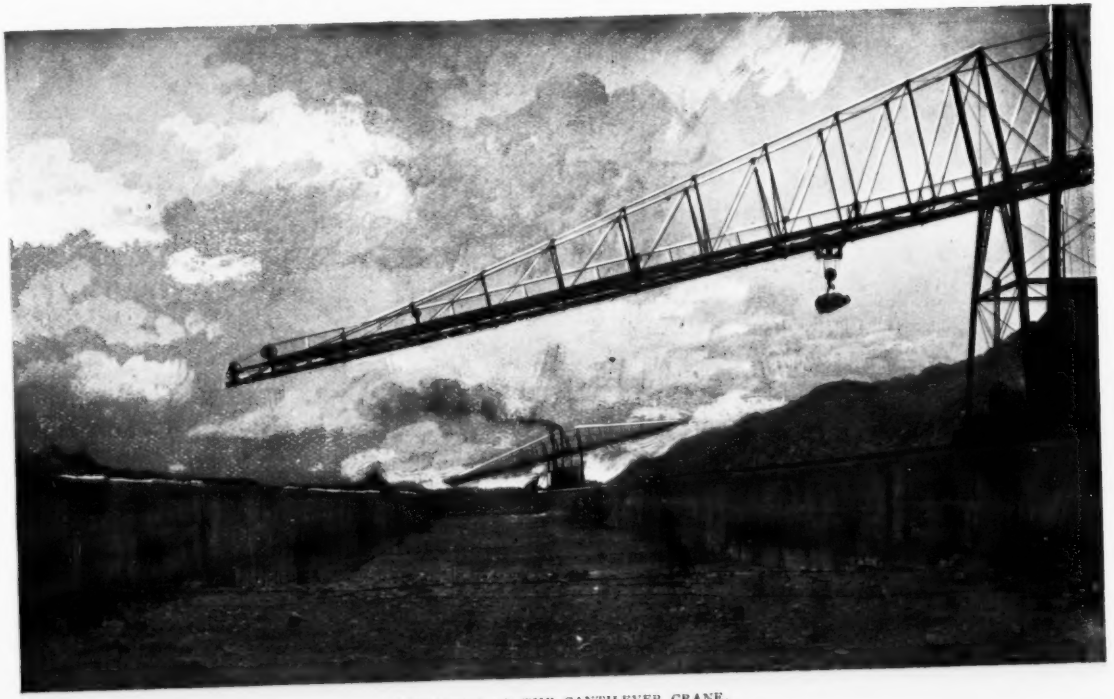
The physical conditions which make this artificial channel possible are of interest. The configuration of the earth's surface in the vicinity of Chicago indicates that the outlet of the great lakes was once to the westward. A river two miles wide and 150 feet deep once swept through a valley which was hewn out of solid rock between the site of

EXCAVATING IN EARTH FOR DRAINAGE CHANNEL AND WATERWAY—ONE-THIRD REQUIRED DEPTH.

Chicago and that of Joliet. Nature may cover up the evidences of her prehistoric operations, but she does not obliterate them. A cross-section of this former outlet is like that of a giant trough. Its outlines are clearly marked and the grooves worn in the rock by the swiftly-flowing stream—aided, perhaps, by ice and glacial débris—are plainly visible. As the waters in the great North American basin were drawn down by the two outlets, one to the east and the other to the west, the rocky barrier in the path of the latter at length resisted the diminishing force of the corrosion, and the surface of the lakes fell below the bed of the western stream. The St. Lawrence thus became the sole permanent outlet for these inland seas.

Chicago stands at the summit of the watershed which separates the basins of the two river systems of the St. Lawrence and the Mississippi. Within the boundaries of the city there can still be traced the bed of a shallow lake, two miles long and half as wide. Its site is the extreme summit of the watershed. In times of drought, within the recollection of the present generation, Le Petit Lac, as the early French traders called this shifting body of water, became first a stagnant pond and then a stretch of wet prairie. In floods its waters divided at the middle. One half started on its long journey to the sea by way of the chain of greater lakes and the St. Lawrence, and the other sought a universal level in the Gulf of Mexico. The Chicago river was the immediate outlet of this summit lake at its eastern extremity and the Desplaines river at its western. The former reached Lake Michigan in a flow of less than a dozen miles. The latter crept over the level bed of the ancient outlet a distance of twenty miles and then descended to meet the Kankakee. The Illinois, formed by the junction of the

EXCAVATING IN THE SOLID ROCK.



OPERATION OF THE CANTILEVER CRANE.

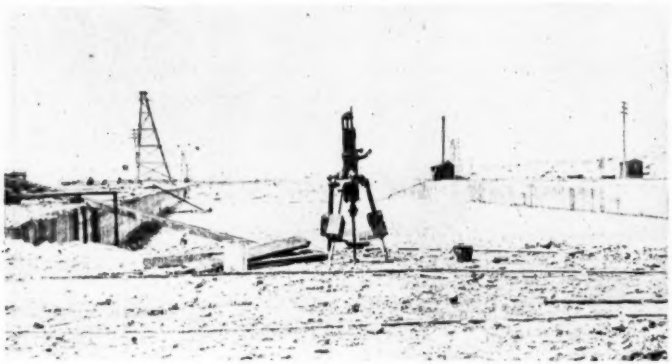
NEW CHANNEL FOR THE DIVERSION OF THE DESPLAINES RIVER.

DESPLAINES RIVER SPILLWAY, NORTH OF SUMMIT.

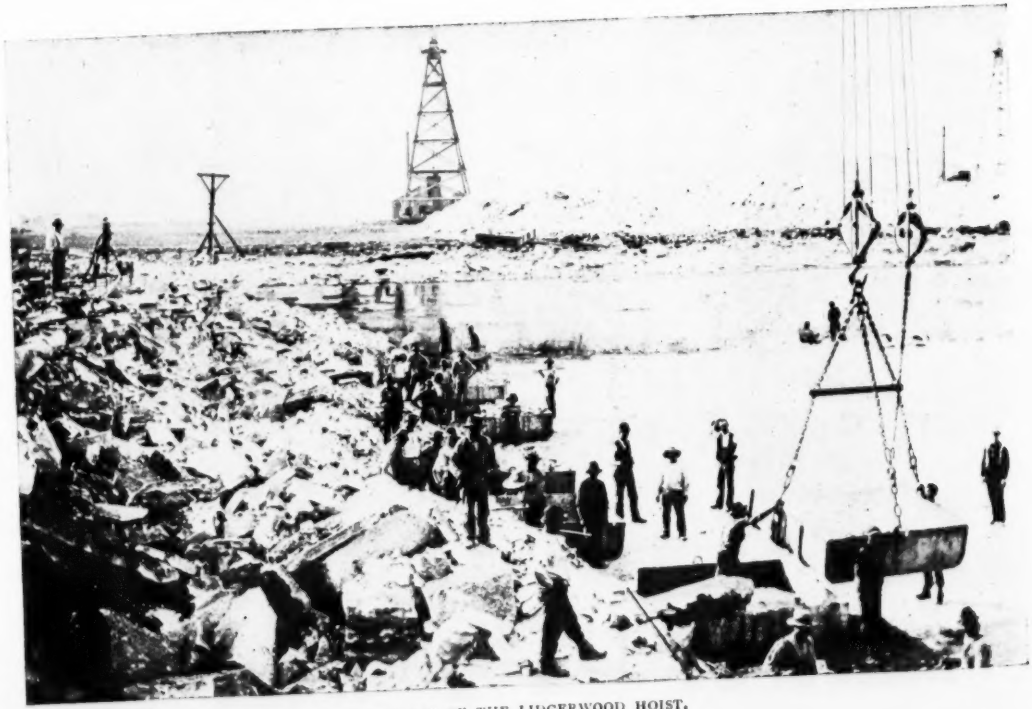
SYSTEM USED ON SECTION 9 OF THE DRAINAGE CHANNEL—TWO DERRICKS AND TWO CONVEYORS.

Desplaines and the Kankakee, dragged its course lazily through the alluvial deposits in the valley of the ancient stream, and lost its identity in the Mississippi at the present site of Grafton, Illinois—320 miles from Lake Michigan.

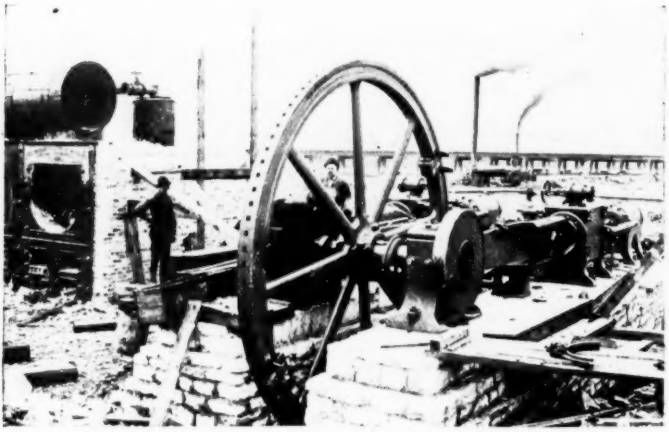
At the time of the advent of white men it was thought that a permanent waterway between the great lakes and the Mississippi could be effected by cutting a channel through the bed of the then partially-extinct summit lake, connecting the Chicago river with the Desplaines. Joliet, who with Marquette discovered the valley of the Desplaines in 1673, was impressed with the apparent practicability of such an undertaking, and he is reported to have said: "We can quite easily go to Florida in boats, and by a very good navigation. There would be but one canal to make, by cutting only one-half a league of prairie, to pass from the



ROCK-DRILLING ON THE DRAINAGE CHANNEL.



THE USE OF THE LIDGERWOOD HOIST.



COMPRESSOR PLANT USED ON SECTION 8, DRAINAGE CHANNEL.

Lake of Illinois (Lake Michigan) into St. Louis river (the Desplaines)." It has since been the dream of many an enthusiast that a navigable stream could again be made to flow through this natural channel to the Mississippi. Practical men have thought that they could see in it commercial advantages which would benefit the entire coun-

HYDRAULIC DREDGE ON SECTION 6 OF THE DRAINAGE CHANNEL, IN 15 TO 20 FEET OF SOFT MATERIAL.

REMOVING EXCAVATED MATERIAL BY MEANS OF A BELT.

try. The question has been earnestly advocated for more than a hundred years. The importance of a serviceable waterway was recognized in a treaty made with the Indians in 1795, when the latter agreed to afford "free passage by land and by water.....from the mouth of the Chikago to the commencement of the portage between that river and the Illinois and down the Illinois river to the Mississippi." The subject was brought before congress in 1804 and has occupied the attention of that body many times since.

ISHAM RANDOLPH.
[Chief Engineer Chicago Drainage Channel and Waterway.]

It was soon found that the short cut through the narrow portage which separated the Chicago river from the Desplaines would be insufficient. The first examination by engineers revealed the fact that the bed of the Desplaines was the solid rock of the ancient river-bottom and that it was seven to ten feet higher than the surface of Lake Michigan, the latter being subject to irregular fluctuations. Furthermore, this rock was found to extend through the greater part of the distance between the summit lake and Lockport, twenty miles farther west. The difficulties in the way of the construction of an artificial channel which should have real value were thus increased immensely. But the engineers reported the work practicable.

The estimated cost of construction varied according to the skill and temperament of the engineers. One found that it would be less than $1,000,000. Five millions was believed to be an extravagant estimate. Beyond the rock formation little was believed to be necessary except to dredge the Desplaines and Illinois rivers, with which the artificial channel would connect.

With the aid of a grant by the United States government of every alternate section of land along the route of the proposed canal, the state of Illinois, in 1836, after thirteen years of preparation, began its construction. Its width was to be sixty feet and the depth of water six feet. It was expected that the waters of Lake Michigan would flow through the canal by gravity. But it was afterward found that this would require a cut through the solid rock fifteen to eighteen feet deep. After spending nearly $5,000,000, with a prospect of bankrupting the state, the deep cut was abandoned and the canal completed on a higher level. Water was supplied by pumps erected at the junction of the canal and the Chicago river. The artificial construction was continued to La Salle, a hundred miles from Chicago, where connection was made with the Illinois river. The canal was completed in 1848, at a cost to the state of $6,569,000.24. It was deepened across the "Divide" in 1871 sufficiently to create a gravity flow from Lake Michigan. The latter work was executed by the city of Chicago to secure the advantages of drainage, and cost $3,300,883.71, making the total expenditure in the construction of the canal nearly $10,000,000.

For a few years the Illinois and Michigan canal served well both commercial and drainage purposes. Both state and city were benefited. When the canal was begun, in 1836, the population of Chicago was only 3820. The sale at a low price of the lands contributed by the general government and the commercial advantages which the canal promised attracted settlers from the east, so that, in 1848, when the work was completed, the city's population had increased to 20,023. Five years later it was more than 60,000. The population of Illinois state doubled in the ten years from 1830 to 1840.

Within a few years after the deepening of the canal it became necessary again to resort to the use of pumps at the head of the channel. The growth of the city had so increased the amount of sewage discharged into the Chicago river that the latter became unendurably foul. The canal was still too shallow to draw off the water of the river rapidly enough to keep it clean. These pumps were put in operation in 1884 and raised 60,000 cubic feet of water per minute from the river into the canal. The relief was still inadequate, owing to the remarkable growth of the city. The river soon became worse than ever.

It remained, as it had been for thirty years, Chicago's one great curse. It was a perpetual theme for preacher and editor. The people held indignation meetings and stormed over an evil whose radical cure they were unwilling to undertake. Finally, in 1886, the city council authorized the mayor to appoint a Drainage and Water-Supply Commission, to be charged with the duty of devising a plan for permanent relief, and Rudolph Hering was placed at the head of the commission. After an expenditure of $65,000 the commission was disbanded, having completed only the preliminary work.

But two facts at least had been established. The sewage of the city could not be safely turned into Lake Michigan if the water-supply were derived from the same source, and it could not be disposed of on land without enormous expense, although there were thousands of acres of barren land in the immediate vicinity. Chemical treatment of the sewage was also found to be impracticable. Without having worked out the details the commission came to the conclusion that Chicago's sewage must be discharged into the Mississippi river through the valleys of the Desplaines and Illinois. But it should first be so diluted that it would not be an offense to the people living in the interior of the state.

There was good reason for an expression of respect for the rights of others. As the sewage drifted lazily down the canal, scarcely attenuated by dilution, it passed directly through Joliet, a city of 25,000 inhabitants, and other towns of smaller size. The gases set free by its decomposition were the cause of considerable sickness. The offensive odors could be traced as far as Peoria, 120 miles from Chicago. The growth of intervening towns was checked, and some of them would have been depopulated. All were fairly ready to take up arms against the metropolis of the state. They had the sympathy of the whole state outside of Cook county. An appeal was finally made to the legislature for redress. This appeal, fortified by the urgent demand of many of the citizens of Chicago for authority to adopt a suitable remedy, led to legislation in 1889 which provided for the construction of a combined drainage channel and waterway between Chicago and Joliet. At the latter point, it was assumed, the Desplaines river would be able to receive the water brought down to it until plans were perfected for the continuance of the navigable channel to the Mississippi.

Such was the origin of the channel which Chicago is now constructing. As a waterway it will provide an easy passage for the largest of lake-steamers and river-steamboats. Ships of the sea will be able to navigate it when access is provided. It will be as large as the largest of modern canals. It is not likely to cost as much

as the Manchester ship-canal, but it will rank with that undertaking in commercial importance.

It is a corollary of the legislation by the state of Illinois that the United States government will continue the enlarged channel from Joliet to the Mississippi by improving the Illinois river. It is supposed that the government will be easily persuaded to complete the work, because of the fact that millions of dollars have been wholly wasted already in attempting to improve that river by a system of slack-water construction. After twenty years of such effort the river is in a more impassable condition than ever. The national government has been urged by the state to stop work of this kind, tear out the dams already built, and create a channel by dredging comparable with the one Chicago is now constructing. When that is done the latter will be turned over to the United States, the continuous channel from Lake Michigan to the Mississippi to become a free waterway.

As a drainage outlet the new channel will insure for Chicago a continuance of its low death-rate. The city will possess an unrivalled water-supply, and a drainage system superior to that of any other large city in the world. When the current of the Chicago river has been turned permanently backward and is fed by a constant flow of water from the lake, that offending receptacle of concentrated filth will become, by comparison, "a clear, sparkling stream," such as a visitor found it in 1833 when the village of Chicago was just emerging from the chrysalis of a trading-post. It has been shown that sewage is rendered practically harmless after a few hours' gentle flow. The people living in the valleys below will hardly have reason to complain of the ill effects and annoyances of the sewage in its new condition.

To construct the enlarged channel the legislature authorized the creation of a distinct municipality, to be known as the Sanitary District of Chicago. Chicago had reached the limit of taxation under its charter and could not itself incur the expense. By this technical evasion the municipality was made to include the greater part of Chicago and such adjoining territory as might be necessary to the execution of the drainage scheme. Its extent is about 185 square miles. The $25,000,000 necessary for the execution of the work is intended to be raised by taxation and the sale of bonds.

The length of the channel from the Chicago river with which it connects at Bridgeport, Chicago, to Lake Joliet, a deep pool just below Joliet, is thirty-six miles. Plans have been completed and adopted for all except seven miles at the Joliet end. This stretch includes the declivity between Lockport and Joliet and the route through the city of Joliet. Contracts have been let for about twenty-six miles, and the work has so far progressed on some of the sections that it

could be completed within a year. There had been paid for construction to March 1, 1894, $2,688,097.84, and for land for right of way, $1,949,198.89. It is estimated that the additional land needed for right of way will cost $1,000,000, and the construction at the Joliet end $1,000,000. The estimated cost of bridges, etc., is $1,000,000. The face amount of the contracts let, based on the estimates, is $16,052,686.82. The estimated face of two contracts yet to be awarded is $638,183, making a total of something less than $22,000,000 as the cost of the completed channel from Bridgeport to Lake Joliet. The remaining $3,000,000 which will be available will be needed in perfecting the communication with Lake Michigan at the eastern end.

In the construction of the twenty-six miles of channel now under contract it is estimated that the glacial drift to be removed will amount to 25,621,489 cubic yards and the solid rock to 10,808,353 cubic yards. There will be needed 276,526 cubic yards of retaining-walls. The prices for which contractors have undertaken excavation in glacial drift range from 20 to 30¼ cents per cubic yard, and in solid rock from 73 to 86 cents per cubic yard. By the use of the latest improved machinery contractors appear to find a good profit even at these unusually low prices, and are able to push the work with unexampled rapidity. By the use of such machinery the number of men needed is greatly reduced, but it is expected that not less than 10,000 will be engaged upon the works of the sanitary district during the present summer.

Chief Engineer Randolph, of the sanitary district, recently prepared a statement concerning the work, in which he says:

It is expected that the channel will form a much-needed extension of the harbor facilities of the city, and be adequate for any future development of lake navigation or deep-water connection with the Atlantic ocean. To this end the channel may be readily widened in the earth and the right of way will be sufficient for any such development. The effect of the large volume of water in the Illinois river will be to give an effective river navigation throughout the 227 miles of the lower Illinois, without obstructing locks and dams, sufficient for the largest classes of Mississippi-river steamboats from the Mississippi to Utica, with very slight improvement on some of the north bars. Thus the first result will be to bring lake and river navigation within sixty miles of each other, whereas they are now practically 320 miles apart. It is estimated that an expenditure of about $6,000,000 will provide fourteen feet of water below Utica in a channel over 300 feet wide. No works have been projected for the intermediate section between the end of the main drainage channel and Utica, over which a descent of some 140 feet must be provided for by means of locks. The consideration given the matter warrants an estimate not exceeding $15,000,000 for a navigation of fourteen feet. It will be seen, therefore, that the expenditure now contemplated by the sanitary district, especially when the channel through the city is provided for, is much larger than that required to complete the work to the Mississippi. In other words, the cost of the first forty miles is greater than the next 280 miles. With the improvements now in progress by the Mississippi river commission, it is anticipated that boats of a draft of fourteen feet will be able to reach the gulf for over

seven months of each year, or for a period longer than lake navigation is open via the straits of Mackinaw, and that the route will be closed by ice for an average of seventy days only. Since 1887 the route would have been open throughout the winter for five years out of six. The state policy underlying the legislation evidently contemplates that the entire project in its larger purposes shall be carried out by the coöperation of the sanitary district, the state, and the nation. It is a part of the policy of the [drainage] board to enlist these forces in proper time.

In the organization of the work a department of health was created. The sanitary inspector, its chief officer, is empowered to enforce rules regulating overcrowding in the camps, ventilation, the use of good food and wholesome water, and the disposal of waste. A hospital service with headquarters at Lemont—midway between the two extremities of the channel—cares for the sick and injured. There has been an entire absence of epidemics thus far, and few serious injuries. To insure order among the workmen, and for the protection of the work in progress, a police department was also organized. Several police-stations were built along the line of the canal and the entire right of way of the sanitary district is patrolled night and day. The affairs of the sanitary district are in the hands of nine trustees who are elected by the people and hold office for five years. They are paid salaries of $3000 a year, the president receiving $1000 additional. The members of the present board are successful business men, or men of established reputation in the professions. They find it necessary to devote nearly all their time to the affairs of the district.

Several changes have been made in the office of chief engineer since the organization of the first board. The first incumbent was Lyman E. Cooley, who was afterward elected a trustee of the district and is now a member of the board. He was succeeded by W. E. Worthen of New York, who was succeeded in turn by S. G. Artingstall, Benezette Williams, and Isham Randolph, the last being the present incumbent. General John Newton, of New York, was consulting-engineer during the incumbency of Mr. Worthen.

The most serious of the unsettled problems with which the board of trustees has to deal involves an adequate connection between the channel and Lake Michigan. The Chicago river, with which it communicates at Bridgeport, is narrow, shallow, and tortuous. Navigation through it is impeded by bridges. It cannot supply more than 300,000 cubic feet of water per minute, one half the required capacity of the drainage channel, without creating a current that would render navigation impracticable, if not impossible. The river cannot be widened without enormous expense, since the shore-lines are built up to the water's edge.

The distance from the eastern extremity of the channel to the lake in a direct line is about three miles. An extension along this line

seems prohibitory on account of the great value of the property through which it would run and because of the network of railroads which intervenes. Such an extension would also cut off the entire southern part of the city from the central business district. An irregular, circuitous route to the southward, striking the lake in the vicinity of Eighty-seventh street, the southern boundary of the sanitary district, is the only reasonable alternative yet suggested. Such an extension of the channel would afford drainage for the so-called Calumet region—the Calumet-river basin—for which no provision has yet been made.

Before work on the main channel was undertaken it was necessary to divert the Desplaines river to a new bed throughout a greater portion of the distance between Summit and Lockport. This work was of considerable magnitude. In floods the Desplaines has always overflowed into the Chicago river and helped to drive the city's sewage into the lake. Its waters are now entirely under control.

ELECTRICITY DIRECT FROM COAL.

THE GREATEST PROBLEM IN ELECTROCHEMISTRY.

*By Dr. William Ostwald.**

THE ground on which applied and abstract electrical science are soonest likely to unite for joint work is that province in which all of us expect to see the next great phase of the application of electrics to technical problems: the province of electrochemistry. The auspices for such a union are uncommonly favorable at the present time. That problem of a hundred years' standing, "the Voltaic pile," has just been solved. By our newly-acquired knowledge of some constants we can now predetermine and very closely approximate the electromotive force of any pile howsoever composed, and regarding the conductivity of electrolytes also we have a very thorough knowledge.

The researches in electrochemistry made during the last few years have led to a complete reversion of all previously-accepted notions as to the condition of substances in solution; for instance, in place of chlorid of sodium bound together by the strongest affinities, a solution of common salt is made out to contain free atoms of chlorin and sodium. What then are the facts forcing us to such an unheard-of opinion?

Imagine a dilute solution, for instance, of chlorid of sodium in much water. Such a solution, containing say one-half of 1 gram of common salt in one liter of water, is still a very good conductor. The conduction of electricity, however, takes place in this way: the ions (*i. e.*, the ingredients of the salt) carry it off; the sodium must needs transport the positive, the chlorin the negative electricity. For in electrolytes, according to Faraday's law, electricity moves only with the ions. Let us more fully dwell on this movement.

If we assume again the above-mentioned concentration, the solution contains to each atom of chlorid of sodium 1000 atoms of water. For equal distribution, therefore, we find in each line ten atoms of

*Dr. William Ostwald occupies the chair of chemistry and electrochemistry at the University of Leipsic, Germany. By invitation of the German Institute of Electrical Engineers he read before that body at its second annual meeting (June 7–9, 1894) a paper on "The scientific electrochemistry of the day and its future technical application." The paper deals broadly with all the latest developments and is a perfect mine of new results and methods of research. Our attention was called to this glimpse into the twentieth century by Mr. Julius Meyer, a consulting engineer of New York, who has abstracted and translated for the Magazine that part which treats of the galvanic coal element.—THE EDITOR.

water alternating with two atoms of chlorid of sodium; consequently, if conduction is to take place, assuming even conduction to be a mutual exchange of ions, each atom of chlorid has to traverse five times the atomic distance before encountering an atom of chlorin with which to unite. Look at it from whatever side we please, we cannot help conceding the independent existence of atoms of sodium in the watery solution and this, at that, for a longer time than they exist in combination. More than that, however, is not claimed by the theory of dissociation either. Thus, by means of a series of different methods, which are a check one on the other, we are enabled at present to accurately determine the part played by an electrolyte divided into its ions.

As a result we obtain a very simple rule for electric conductivity: in any electrolyte the conductivity is proportional to the quantity of ions contained in the unit of volume and, furthermore, proportional to two constants, which may be called the velocity of ionite migration. The velocity is a maximum for hydrogen. I shall not now enter any deeper into this matter, though it is not without interest; for of higher interest yet is the research for the electromotive forces, and this question has been solved by similar methods.

The basis of all discussion in this field of research is the osmotic pressure, and I shall explain first what this is. Five or ten years hence this would hardly be necessary, for then every person of scientific attainments will be as conversant with it as with gas-pressure. It is well known what happens when we superimpose pure water on a concentrated solution of any substance: the dissolved substance moves into the water. This movement or diffusion continues until everything is equally distributed. The cause which produces this movement and which is in the nature of a pressure is just what we call osmotic pressure. If one wants to convince one's self that one is dealing with a real pressure it is necessary but to prevent the movement of the dissolved substance. We should need to this end a partition impervious to the dissolved substance but not to the dissolving medium,—*i. e.*, water. It is not an easy task to produce such partitions, but in some cases it has been successfully done, and especially Professor Pfeffer has demonstrated by what means it can be accomplished. Employ such a partition and we will find the resulting pressures astonishingly high. A solution of salts such as the water of the ocean contains would exert a pressure of twenty atomospheres. Whence the pressure comes we need not discuss now; suffice it to say the pressure exists and is a property of all dissolved substances.

Any solid brought into contact with a fluid in which it can dissolve is capable, of course, of producing such a pressure. It is only necessary to envelop it in the above-described manner and, if we make

the semi-pervious envelop so strong that the pressure cannot burst it, a maximum value of the pressure will finally be reached, depending on the solubility of the solid, and which can not be exceeded. This pressure is quite analogous to steam-pressure, and just as we utilize the latter in engines we can conceive of machines being operated by osmotic pressure. Well, a galvanic element is such an osmotic machine and it will now be perceived why I have gone to all this length to explain it.

In order to fully understand, however, we shall still have to investigate the process of the dissolution of metals in galvanic elements. Zinc dissolves into sulphate of zinc. In the sense of the above-discussed conception the process involves the formation of electrically-charged zinc-ions from the unelectric metal. Simultaneously, however, if we base our contemplations on the Daniell cell, just as many copper ions enter into the unelectric condition,—*i. e.*, become ordinary metal. Positive electricity must, therefore, constantly be bound on the zinc electrode and the same amount be discharged on the copper electrode if the process is to take place at all; consequently, if we connect the two metals conductively an electrical process will occur simultaneously with the chemical process and neither of them can take place without the other one.

The reader is now conversant with the analogy between the pressure and the electromotive force. Precisely as we might operate a mechanical engine by means of two fluids of different steam-pressure, just so we may operate an electrical machine by means of two sources of different electrical pressure or potential. The zinc and copper of the Daniell cell are two such sources of current of different potential and the difference of their electrical pressure is based on the difference of osmotic pressure with which the zinc ions and copper ions are respectively endowed. The stronger the working pressure of the zinc and the weaker the reacting pressure of the copper, to be overcome, the more favorable the element,—*i. e.*, the higher is its electromotive force.

The pressure with which a metal tends to go into solution,—or its "dissolve-pressure," as we shall call it after this,—has a certain fixed value for every metal, and it might appear as though the two metals only and nothing else had to be considered in constructing galvanic elements. This, however, is not the case, and the impression is created simply because into this question enters another factor which has not yet been mentioned.

When the electrode of zinc is in contact with the liquid the effective dissolve-pressure clearly not only depends on the zinc, but there are zinc-ions in the solution which exert a reaction and can become

effective only in the proportion of the excess of the first pressure over the latter. The electromotive force of the zinc, therefore, is the greater the smaller the reaction of the zinc-ions,—*i. e.*, the smaller the concentration in regard to zinc. It is well known, in fact, that the electromotive force of the Daniell cell is greater with sulphuric acid than with sulphurate of zinc.

The conditions are the reverse for copper; here it is advantageous to have the concentration of ions as great as possible, for a great pressure on this side assists the separating of copper.

These simple reflections constitute in the main the theory of the galvanic element. Originated by Professor Nernst, this theory differs from former so-called theories in that it does not approximately demonstrate prevailing conditions, but, comparable to Newton's law of gravitation, furnishes a quantitative theory controllable down to the most insignificant details. For this theory results in quite definite conclusions for definite premises and cases which at present can not yet be fully calculated are in that condition, not by defects of the theory but simply because the integration of the differential equations, which are known, has as yet been prevented by mathematical difficulties. Otherwise only the determination of the ruling constants is still lacking; quite a number are known even now, but of course some hard work has still to be done in this direction. Thus theory furnishes the means of finding the most suitable combination of substances for galvanic elements.

But there are problems of greater importance for electrochemistry to solve. We all know the defectiveness of our most common source of energy, the steam-engine. Under the most favorable conditions we realize of the energy stored in the coal but 10 per cent. in mechanical work. And we also know that the heat cannot be entirely transformed into mechanical energy, but we can calculate the fraction which is obtainable from a given quantity of heat of a certain stated temperature when we allow it to fall to another also stated temperature—and here again we find the utilized energy to be but one-seventh of the amount that might be transformed. This poor result is not chargeable to the steam-engine as a technical apparatus; the cause is found in the utilization of only the smallest part of the high temperature of the combustible, which at a low estimate is 1000 degrees, viz., that part between the temperature of the boiler and the temperature of the condenser. All that enormous difference of temperature between the combustion-chamber and the boiler is a total loss. There is only one way of improving thermodynamic engines: higher initial temperatures. How to accomplish that is for the technologist to find out.

But thermodynamic engines are not the only ones in existence and

temperatures of 1000°, which it is certainly no small matter to handle technically, are not unavoidable. The maximum of energy that can be obtained by any one change of energy is theoretically independent of the process by which the change is effected. Therefore, if we could transform into mechanical energy the chemical energy of the combustible without resorting to heat, we should not be tied then to the uncomfortably high temperatures and might gain the entire amount without those discomforts.

The path on which this greatest of all technical problems—the production of cheap energy—can be approached; that path must be discovered by the electrochemist. If we produce a galvanic element which furnishes electrical energy from coal and the oxygen of the air and furnishes it in amounts somewhat in proportion to the theoretical values, then we shall face a technical revolution in comparison with which the one following the invention of the steam-engine will be dwarfed into insignificance. Think of the incomparably simple and elastic distribution of electric energy and imagine the change in the appearance of our industrial centers! No smoke, no soot, no boilers, no steam-engines, nay, even no fire, for fire will be needed only in the few processes which cannot be accomplished by electricity, and of those there will be fewer every day.

How the galvanic element in question will be constructed, of course, cannot even be surmised at present. Let me point out, however, an essential feature which is almost invariably misunderstood. The energy of the galvanic element originates in the chemical energy; that is indubitable. But not all chemical energy is changed into electrical energy. What then are the conditions for which the transformation is as complete as possible? Only the indirect chemical processes are electrically utilized!

Suppose we should take two vessels containing each a solution of potassium sulphate and connected by a filled siphon. We put a rod of zinc into the one and a rod of platinum into the other vessel. If we connect the two metals over a galvanometer a current of but very short duration occurs and the needle of the galvanometer comes directly to rest again. We know this to be the consequence of the polarization and also know that a continuous current may be obtained by the employment of an acid in place of the neutral fluid. Suppose we employ sulphuric acid. Into which of the two vessels would you want me to pour it to produce a current? Whosoever had this question put to him unhesitatingly answered: to the zinc of course, for the zinc must dissolve! But, my asking the question may convey the hint that the matter is different. We pour the acid to the zinc—no action! We pour it to the platinum, and we perceive the needle fly to the stop.

We arrive thus at the seemingly absurd result that the acid must be poured into the vessel not containing the substance on which it is to act. That applies quite universally. Some years ago I published a long series of experiments which proved the validity of this principle for entirely different reactions. And that is by no means an unforeseen or unexplainable fact, but the experiments were made because I had to expect the demonstrated phenomena from the theory which at that time was only just shaping, although at first blush they appeared scarcely plausible.

But if we bestow some more thought upon the nature of these processes we soon perceive that they could not possibly take a different course. If the zinc is to dissolve it must form ions and to that end take up a certain quantity of positive electricity. To make this possible an even quantity of positive electricity must leave the solution, so that an equivalent quantity of hydrogen relinquishes its ionite existence and is transformed into common hydrogen. The discharge by the fluid of positive electricity can not take place at the spot where zinc dissolves, for there the electricity is moving in the opposite direction. There is therefore no alternative but for hydrogen to escape at the cathode conform to the actual occurrence.

The explanation plainly shows the futility of the procedure of the late Joblochkoff when, some years ago, he tried to produce electrical energy from coal direct. He put the coal into melting niter from which to obtain oxygen and the resulting violent combustion actually generated current, but so weak a one that it could not be utilized. Now we clearly perceive the reason of his failure: the niter does not belong with the oxidable electrode, but with one not attacked by oxygen. Surely in the Bunsen element we do not pour the nitric acid on the oxidable material, zinc, but on the coal, which under these conditions is not oxidable.

Therefore our future coal element will have the oxidizing medium on the side not containing the coal to be burned, and that medium must either be the oxygen of the air itself or some other oxidizing substance produceable in quantities from the same. In its chemical process such an element would be like an ordinary stove. Coal is shoveled in at one side and oxygen admitted from the other; carbonic acid escapes as product of the reciprocal action. A suitable electrolyte has still to be added to bring about the electrical process. The electrolyte only acts as an interposed substance and will not be consumed.

This is not the place to detail the technical features which might lead up to the desired result; it will be some time hence before we shall be able to seriously cope with this problem. But I will say this

much: we are not chasing rainbows, but we are dealing with a case the success of which is as much within our horizon as that of any other mechanical problem. It is left to technology to find the cheapest and best form for its practical application.

The work of science in a case like this is positive as well as negative; it shows what can be accomplished, or it may say; "this can surely not be done." The work of the inventor, however, is not superseded thereby. Science answers only yes or no, when interrogated, and in many cases it has no answer at all. The inventor has the difficult task of shaping the problem and advancing it to the point where the question may be put to science—and when it is put, how many times is science forced to confess: That has not yet occurred to me!

ELECTRIC WELDING AND METAL-WORKING.

By Hermann Lemp.

SO many able papers have been published on the subject of electric welding and electric metal-working that there would seem to be nothing more to say on the subject, in a general way; but so far as individual appliances and experience are concerned, much more may be said.

Before entering upon the study of the art of electric welding and metal-working as originated by Professor Elihu Thomson, I will endeavor to review all known attempts and processes of electrically heating metals, and shall consider myself justified in devoting to the Thomson process the principal part of this paper.

With the commercial introduction of the arc-light (in 1881) one of the first characteristics of the arc noticed was its great localized heat; it was, indeed, this very heat that was necessary for volatilization of carbon. Metals heretofore known to be refractory to melting processes, such as platinum and the like, would be melted down with ease whenever introduced into the path of the arc.

Werner Siemens, then the pioneer in electric-lighting in Europe, constructed the well-known electric furnace for the melting down of ores or metals requiring the very highest temperatures. It consisted of a conducting crucible of graphite which was made one of the poles of a powerful continuous-current dynamo, while the other terminal was connected to a piece of circular carbon, held centrally with respect to the crucible. The two poles were first made to touch, and then an arc was drawn by withdrawing the central carbon. Any ore or metal thrown into the crucible would be under the direct influence of the arc, and be melted with ease. The crucible generally formed the positive pole. This process, free to every one, is quite practical for laboratory work, especially for experimental alloying of metals. The necessary apparatus is simple, and current can be used from any ordinary incandescent-lighting dynamo of the continuous-current type. It may be noted that in this process one electrode may be partly the crucible and partly its fused contents.

The next application we find was made by De Meritens, a Frenchman, who substituted for the crucible the metal object itself; from this an arc was drawn similarly to that in the Siemens furnace. This process, now generally known as the arc process, was further elaborated by a Russian named Bernardos, who not only carried out experiments on a large scale, but through his English sponsors, the well-

known firm of Lloyd & Lloyd, obtained commercial results in two specific lines.

The first of these, the filling of blow-holes in castings, has saved many a costly product which would otherwise be condemned to the scrap-heap. The only precaution to be exercised is to previously heat the casting to be treated to a dull red heat, by an ordinary furnace burning either coke or oil, and then to apply the arc, making the casting the positive pole. If the casting is not heated as described, the filling made by the arc will, in shrinking, break away from the matrix, or will crack.

The second application is to the longitudinal welding or soldering of plates that have already been riveted. Where the metal to be heated is thin, the heat of the arc alone is sufficient without additional means. It is impracticable, however, when the material to be worked is massive and likely to rapidly conduct the heat away from the surface under treatment. Complicated pipe-flanges, Westinghouse air-receivers, etc., have been welded by this process. The electric arc so applied appears to act as an economical and intense blow-pipe. The necessary apparatus is a continuous-current generator of not less than 110 volts (preferably 150), an adjustable resistance in series to modify the strength of the current for various work; a carbon-holder with a shield to protect the operator from the radiant heat of the arc, and a shield for his eyes, consisting of a number of superposed colored glasses. The current employed varies, according to the size of work, from 10 to 350 amperes. No flux is required. This process is, however, limited to but few applications, and, while handy for specialties or repair work, is limited to surface work. It also can be used for chilling the surfaces of soft castings, as, for instance, knife-edges for scales, etc.

In the above methods, the piece to be worked upon forms, either in part or in whole, one of the electrodes from which the arc is drawn.

Another electric-heating process, utilizing the arc and more closely resembling the action of a blow-pipe, is that devised by Werderman, and the apparatus for carrying it out is known as the Werderman electric blow-pipe. In this apparatus, a small permanent steel magnet, or electromagnet in series with the arc proper, exerts a repelling effect upon the arc, which, like the flame of a blow-pipe, may then be directed against an object to be soldered or otherwise treated while hot. This blowing effect on the arc is produced by the effect of two currents trying to produce magnetism in opposite directions. The arc flame, which is a flexible conductor, tries to set itself in harmony with the magnetic field of the electromagnet.

This process has not found any practical application to speak of,

but may, undoubtedly, be of value in specific cases,—for instance, where the oxyhydrogen flame is now used as a source of heat. The cost of the latter, however, is far beyond the running expenses of an arc-light. A somewhat similar effect can be obtained by using an air-blast in the place of the magnet, or the arc may be formed in an inclined position, so that a natural draft carries the flame upward against the object to be heated. Copper wires may be brazed in this manner.

Another application of the arc—one which has not been ascribed particularly to any one person, but has been practised by many—consists in approaching two wires forming the two poles of say a 50-volt circuit, then separating them so as to cause an arc to bridge the gap, in which position they are held awhile until both terminals are at a white heat or melted, and then they are quickly pushed together, after which all heat disappears. The positive pole, as usual, is the hottest, and a large ball forms on the same into which the negative terminal is pushed. The writer used this process many years ago for joining platinum wires to copper wires used in the manufacture of series incandescent lamps, and also, together with Mr. Merle J. Wightman, made use of this principle as a safety device in incandescent lamps running in series with arc-lamps. This process works fairly well for such purposes as these, where electric conduction is required, while mechanical strength is of slight consequence.

Still another process, which has been brought to notice of late in Belgium, has caused a good deal of surprise to the ordinary observer on account of its apparent inconsistency with established experience. It was originated in Belgium, and consists in passing a continuous current through a receptacle filled with a moderately conducting fluid, such as acidulated water, carbonate of potash solution, or the like, contained in a metallic receptacle or a nonconducting vessel lined with lead plates. When an iron bar connected to the positive pole (the vessel being made negative) is plunged into the liquid, an arc is formed around the submerged portion which will bring it to a white heat in a short time. The piece can then be removed and hammered on an anvil, or welded by the ordinary blacksmith's method to another bar similarly heated.

The heated metal seems to be clean and free from dirt and oxid, due doubtless to the protecting film of hydrogen which forms on its surface. The temperature, however, is not easily controllable, and the utility of the process is confined to easily weldable iron, or low grade steel, and to pieces of very simple form. High-carbon steel will be burned. Furthermore, pieces to be welded together cannot be held together while being heated, but must receive heat as in a

blacksmith's forge previous to working. A similar result may be obtained by using, in place of the conducting liquid, a receptacle filled with loose charcoal, graphite, metal oxids in powder, or even melted metal.

The processes just described are chiefly of recent date. Joule, as early as 1856, buried a bundle of iron wires in charcoal, through which an electric current was made to pass. The charcoal thus heated, in its turn heated the iron, which at places was found to stick together. The nearest approach to a practical application of this process is the heating of wires by pulling them through a carbon tube which is kept hot by an electric current. Such a machine was described by Siemens in London, and has also been experimented with by the writer for continuously heating nail-rods.

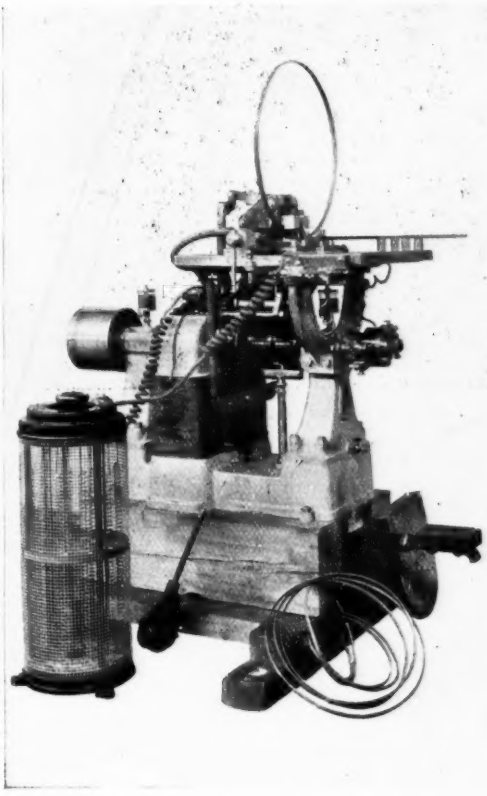


FIG. 1—DIRECT-WELDING APPARATUS.

It will be perceived that, in all the processes described, the object has been to create artificially a high resistance at one point in an electric circuit, and, by employing an electric current of sufficient electromotive force, to overcome this resistance, and in so doing heat the

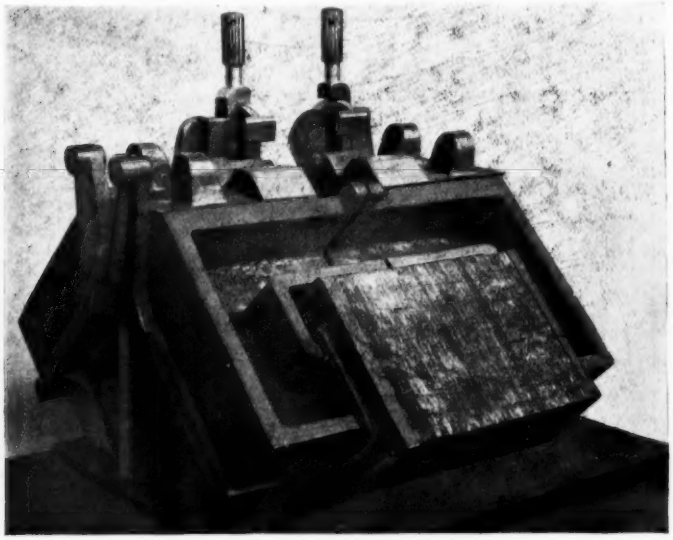


FIG. 2—COMMON FORM OF TRANSFORMER.

point of highest resistance. The difference in resistance between the metal to be treated and the medium through which the current passes has, however, always been so great that the heat has been too much localized, creating only surface heating, which permits the metal to chill at once upon stopping the flow of current. The temperature at the surface is, furthermore, too high and liable to cause blisters.

Professor Elihu Thomson early saw the limitations of the processes mentioned above, and, years ahead of the practical advent of his now well-known process, had its elements clearly in his mind. This process differs radically from all the others in *forcing through the metal to be heated electrically such volumes of current that its own resistance is sufficient to bring every molecule of the section traversed by the current to the desired temperature.*

In the processes and experiments heretofore described, the heat was not generated in the metal or the joint itself, but always either in the surrounding envelop and communicated to it through conduction, or in the contact between the metal and another high resisting medium. In the Thomson process, for the first time, the heat is generated in the metal itself at the joint, and not communicated to it. We will see the importance of this by comparing it with the ordinary forge heat-

ing. In this a bar of iron is inserted in a fire, or put in contact with live coal. The heat communicates itself to the iron by conduction and radiation, and, in proportion to the increase of temperature in the iron, increases its resistance to the further reception of heat from the source. In other words, in heating any object by communicating heat to it from outside a condition is soon reached, after which either more energy or time will be required to further increase the temperature. Now, let us heat the same bar of iron by an electric current; we find that the hotter the iron becomes, the more easily its temperature is further increased. In the former case of heating from the outside, the surface to which the heat is applied is the hottest, and the core or interior where the heat is wanted is the least hot. In the electric process, it is the *core* which is best protected from radiation and which will become heated first. There is, however, another difference more important from the standpoint of economies.

By the forge-fire method, only part of the heat generated is communicated to the metal. In the electric method, heat is generated in the metal itself, and all the energy forced through the metal is usefully applied.

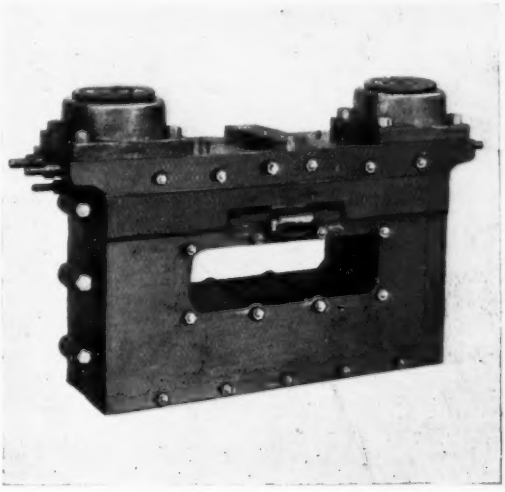


FIG. 3—TRANSFORMER FOR LARGE APPARATUS.

What I wish to show is that in the electric method of heating we can increase the *rate* of heating, or, in other words, shorten the time necessary to heat a piece of metal without sacrificing uniformity, by simply increasing the electrical energy expended in the circuit; while to increase the rate of heating in a fire, we are obliged to sacrifice uniformity, and increase the waste proportionately or more than that. By this electric process, therefore, (1) we utilize, practically, all the energy; (2) we can increase and

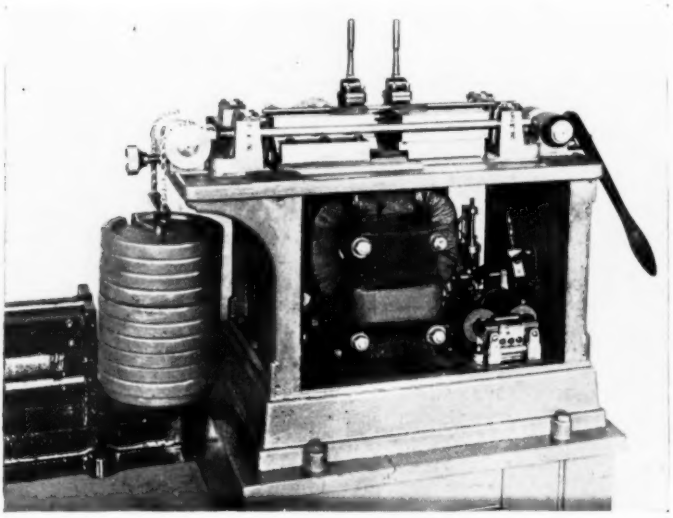


FIG. 4—AUTOMATIC WELDING-MACHINE.

decrease the rate of heating at will; and (3) we can stop all further loss of heat by the simple removal of the metal pieces (the sources of heat) from the circuit, or by switching off the current.

Thomson's welding process consists in passing an electric current of great volume, by means of two clamps of good conducting metal (generally copper), through two pieces firmly abutted against each other between the clamps, which, when heated by the current, are forced together by mechanical pressure. The metal between the clamps alone possesses the requisites for the conversion of electrical energy into heat. The only loss of energy to be counted on will be that caused by conduction of heat to the clamps of the apparatus, by radiation, and the resistance loss in the electric generator and welding machine. By increasing the speed of operation the first two items, which are alone of importance will be reduced.

The apparatus generally used to carry out the Thomson process is—

1. A generator of alternating currents.

2. A welding transformer provided with clamps and mechanical appliances to work the heated metal.

3. Electrical regulating apparatus to control the flow of current.

The generator is best when of a low periodicity. For the past five years fifty cycles per second have been used, and even lower; twenty to

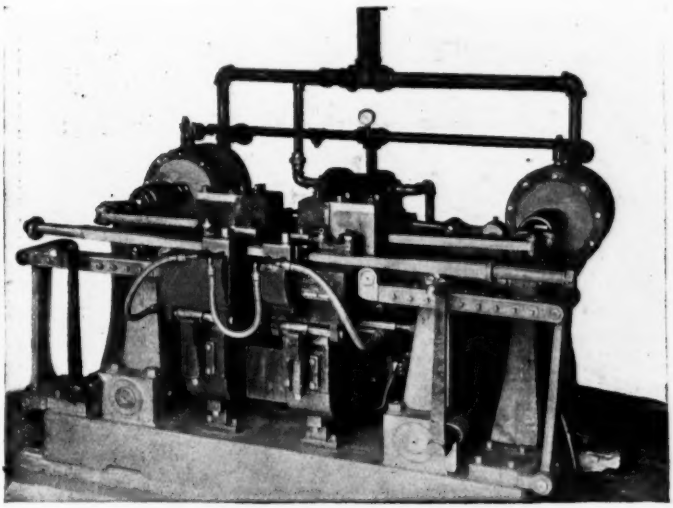


FIG. 5—APPARATUS FOR WELDING CARRIAGE-AXLES.

thirty could be used to advantage on large work, owing to the great self-induction which the work proper creates. When one considers the immense volumes of currents required for welding copper, approximating 60,000 amperes per square inch of metal, he can imagine the density of the alternating field surrounding the conductor. Other things equal, the self-induction will be proportional to the periodicity, and so will be the corresponding increase of current above what would be needed to convey the necessary energy to the metal, if there were no self-induction. The generators are not different from those found in electric-lighting, except in voltage and periodicity. They can be used for lighting if required.

In some apparatus, known as direct-welders and used only for small work, the alternating currents for welding are generated in the dynamo and carried to the clamps directly, without transformation, and the clamps and mechanical pressure devices are all incorporated in the dynamo. [See Figure 1.] The transformer, however, is usually employed in practical work. Through its agency small currents set in motion by high electromotive forces can be converted into currents of great volume with small electromotive forces, just as light belts running at high speed are made to transmit, by means of proper pulleys, the same mechanical energy as slow-running, heavy belts. The product of the feet per second and pull in pounds exerted by the belt measures

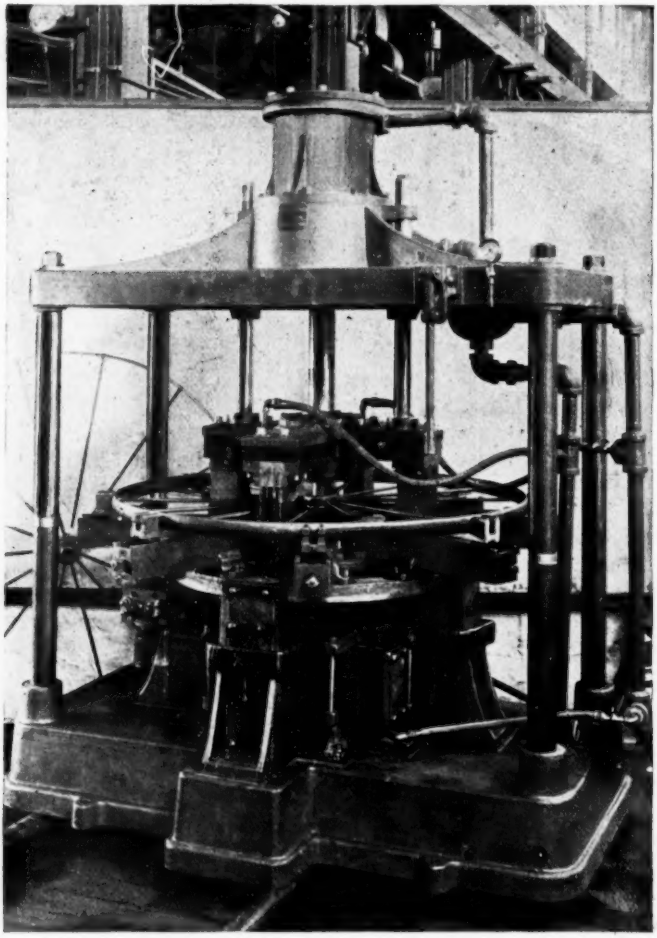


FIG. 6—MACHINE FOR WELDING WHEEL-SPOKES TO HUB.

the energy conveyed. So, roughly, the product of the length of wire and density of current flowing through it may measure electric energy. A belt transmission and electric transmission are analogous, and the latter is explained by the former. The electric transformer is just as simple an apparatus as any set of pulleys,—in fact more so, on account of the

fact that none of its parts are revolving. Friction in a belt transmission is equivalent to resistance in the magnetic and electric circuits.

Slippage is equivalent to what is known as magnetic leakage. An electric transformer in which the two windings are not closely related to each other, which allows a leakage of magnetic lines to take place between them, is comparable to a friction-pulley power-transmission. If the load to be transmitted exceeds the friction, a slip will occur. A properly-constructed transformer is like a positive coupling. It will transmit all the energy put upon it, or break down itself, or cause the generator to break down. This property is obtained by having the secondary conductor of a transformer completely surround the primary.

Figure 2 shows the most common form of transformer. It is a copper casting with either one or two grooves cut at one side ready to receive the primary winding, and its two terminals or poles respectively connected to the pieces to be welded by means of sliding contact surfaces. These forms are generally used in connection with a horizontal table for supporting the work.

For large apparatus, especially when the transformer itself is to be moved bodily to and from the work, the shape in Figure 3 is used. For this construction, the secondary is composed of two halves, which are bolted together with these grooved surfaces meeting. In the hollow rectangular frame thus formed, the primary coil lies both mechanically and electrically protected by the secondary. It is often customary to fill the intervening spaces with oil, which completes the insulating

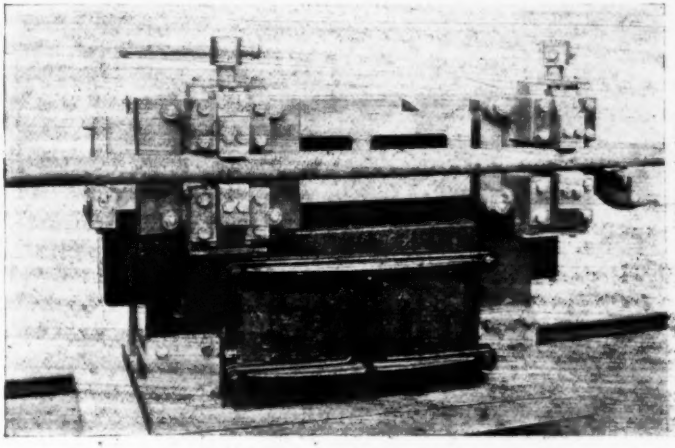


FIG. 7—TRANSFORMER FOR HEATING PIPE FOR BENDING.

FIG. 8—APPARATUS FOR WELDING SHRAPNEL SHELLS.

properties, and permits a free communication of any heat generated in the primary to the outer walls of the secondary, from which it will be dissipated. These transformers have practically no leakage between primary and secondary. The only limiting item to transmission of energy through them is the ohmic resistance of the two windings.

The electric current is generally regulated by means of a reactive evil in series with the primary of welders or by rheostat in the field circuit of generator.

ENERGY ABSORBED IN ELECTRIC WELDING.—PROF. THOMSON'S PROCESS.

IRON AND STEEL.					BRASS.					COPPER.				
Area in □ ″	Watts in Prim. of Welders.	Time in ″.	H. P. applied to Dynamos.	Foot lbs. unit 1000.	Area in □ ″	Watts in Prim. of Welders.	Time in ″.	H. P. applied to Dynamos.	Foot lbs. unit 1000.	Area in □ ″	Watts in Prim. of Welders.	Time in ″.	H. P. applied to Dynamos.	Foot lbs. unit 1000.
0.5	8550	33	14.4	260	.25	7500	17	12.6	117	.125	6000	8	10.	44
1.	16700	45	28.0	692	.5	13500	22	22 6	281	.25	14000	11	23.4	142
1.5	23500	55	39.4	1191	.75	19000	29	31.8	508	.375	19000	13	31.8	227
2.	29000	65	48.6	1738	1.	25000	33	42.0	760	.5	25000	16	42.	369
2.5	34000	70	57.0	2194	1.25	31000	38	52.0	1087	.625	31000	18	51.9	513
3.	39000	78	65.4	2804	1.5	36000	42	60.3	1390	.75	36500	21	61.2	706
3.5	44000	85	73.7	3447	1.75	40000	45	67.0	1659	.875	43000	22	72.9	872
4.	50000	90	83.8	4148	2.	44000	48	73.7	1947	1.	49000	23	82.1	1039

The table on this page shows the energy taken for the three typical materials—iron, copper, and brass—of various sections. The greater the power, the shorter the time, and *vice versa*. Certain materials have to be heated very slowly to prevent over-heating Materials that are changed in nature at high temperature, and that are easily fusible, such as copper, brass, tool steel, etc., are best welded rapidly. There is no opportunity given in rapid welding for deterioration of the metal, and whatever metal has been hurt is pushed out from the joint under longitudinal pressure. This method of rapid welding has come into greater favor of late, and, inasmuch as an increased product is obtained by it, most users disregard the increased first cost of larger machinery on account of the benefit of increased production and uniformity. Under ordinary circumstances, we may say that 7 horse-power-minutes is a safe figure for bringing one cubic inch of metal to welding heat. This is practically the same for copper, brass, and iron, with the distinction, however, that for metals which conduct heat easily, a shorter time and correspondingly greater power must be used to prevent loss from both radiation and conduction. If the pieces to be welded are short and wide making the conduction by the clamps great, from 10 to 15 horse-power minutes per cubic inch are required.

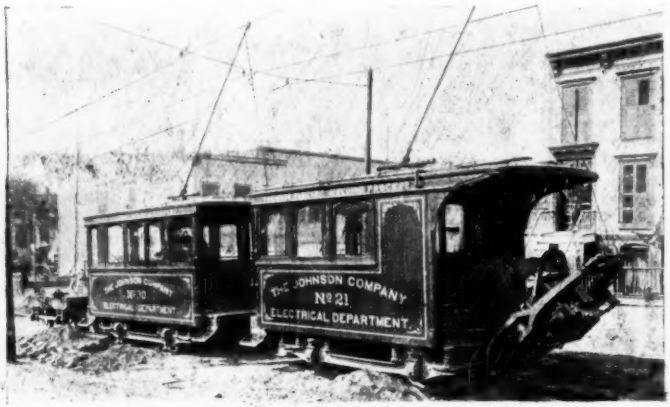


FIG. 9.—JOHNSON ELECTRIC WELDING TRAIN.

In the table just referred to the stock to be welded is assumed to be held in the clamps with a distance between clamps of twice the diameter of round material for iron, three times for brass, and four times for copper. For heating iron or steel bars, as in upsetting or in ordinary forging operations, when of lengths not shorter than a foot, from 3 to 5 horse-power-minutes per cubic inch will be required to bring them to a bright red heat, and from 4 to 10 horse-power-minutes to bring them to a white heat, such as is used in blooms for rolling.

It is interesting to note that calorimetric methods have proved that, of all the electrical energy put into the metal to be heated, fully 75 per cent. is useful. The 25 per cent. missing is mostly lost by radiation and conduction, showing a high efficiency of the electric conversion into heat, and that the actual cost of fuel for welds in an open forge and by the electric process is about equal under continuous working conditions,* while, with discontinuous working, the electric method is far ahead in economy. This has been rather a surprise to many, the question of fuel expense having always been regarded as settled to be greater for the electric process.

The numerous experiments which have been made to store up the energy between welds by means of fly-wheels, storage-batteries, etc., the energy to be returned during welding, have been without practical results. The problem in most cases has been solved by the farsightedness of the American manufacturers in disregarding first cost, and installing apparatus large enough to have a surplus of energy. In every

* See paper read by Sir Fred Bramwell, of E. I. M. E.

FIG. 10—WELDER OF THE THOMSON SYSTEM AT WORK ON THE NASSAU ELECTRIC RAILWAY, BROOKLYN.

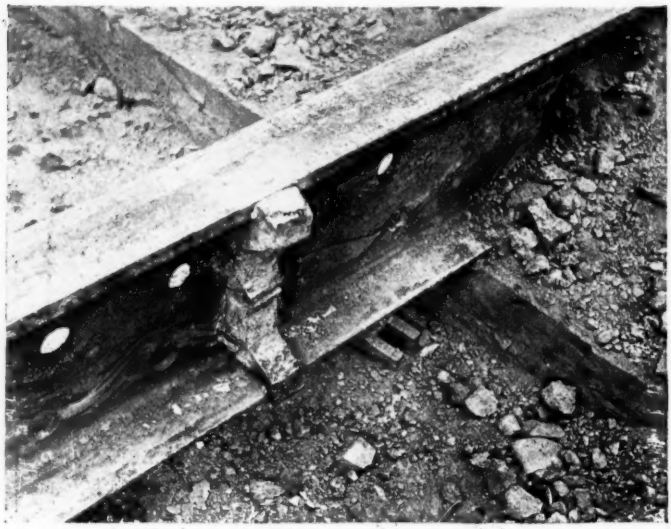


FIG. 11—ELECTRICALLY-WELDED STEEL RAIL.

case this has proved to be the best, but with electric energy directly available from a central station, the manufacturer is able to dispense with the surplus energy, and throw this responsibility upon the central station. A large number of customers, operating from one source of power, will never draw this surplus at once, but the surpluses will overlap each other and out of individually irregular demands will result a fairly even average demand. The electrical energy necessary for welding, can, therefore, in many cases, be obtained directly when within the district of an alternating-current supply, by means of an ordinary transformer, or when within the district covered by the now commonly-employed power-stations, furnishing current of 500 volts, by means of a rotary transformer, more generally known as a motor-dynamo. By means of the latter machine, an amount up to 200 horse power is to-day successfully transmitted for welding street-car rails in the street.

The great advantage of such a device as the motor-dynamo consists in its flexibility and ease of manipulation, and its ability to transmit great overloads for short periods. A steam-engine overloaded stops; an electric motor or transformer, properly constructed, will rise to the occasion, although, if too long continued, it will break down.

The practical applications of the Thomson process to various industries will now be described briefly. Wire-mills were early to recog-

nize the advantages of the electric process for disposing of their shorts, incidental to the manufacture of wire, on one hand, and satisfying the demands of the trade for longer coils. Automatic machines are mostly used for this purpose; that is, machines in which all conditions for good work are automatically maintained without requiring a special experience on the part of the operator. [See Figure 4.] Weights at the left determine end pressure, adjustable stops, the distance between clamps, and knurled screws at the left, the shutting off of the current by means of the magnet shown at the right. Nearly every wire-manufacturer of repute in the United States has either one or more of these machines. The firm of John A. Roebling's Son & Co., in Trenton, are making, on the average, 600 welds per day of ten hours, on telegraph wire. Most of the time is used in the handling of the heavy wire coils, as is seen by comparing the above output with the welding of brass wire loops and steel harness-rings done at the works of the Thomson Electric Welding Company, in Lynn, for outside customers, in which case the daily product of ten hours is 3000 and 1000 welds respectively. The increase in speed is simply due to quick handling of light objects as compared with heavy coils.

Mr. Roebling stated in 1892 that, of more than 1,000,000 welds made by his firm, not a single case of a bad weld had come to his knowledge. Carriage-builders are largely users of the the electric process. Tires, hub-bands, dasher-frames, carriage-steps, and axles are welded in large quantities. Figure 1 shows a direct welder on which baby-carriage tires are welded at the rate of 1500 to 2000 in ten hours.

The hand hydraulic pressure, as used on some of the large machines, may be replaced by a special pump and accumulator controlled by a valve. Such a machine is shown in Figure 5, which was designed to weld carriage-axles of all dimensions up to 2 inches round. Both the clamping of the stock and the end pressure are hydraulic, relieving the operator of nearly all manual work.

The manufacturers of metal wheels have also found it advisable to use the electric process. Figure 6 shows a machine designed to fasten the spokes of a metal wheel in the hub by welding two halves of a hub together, including the spokes between the welded surfaces, and of riveting the spokes in the tire by heating them electrically at their contact with each other.

The much-dreaded welding of high-carbon steel, in the experience of the ordinary blacksmith methods, has, in the Thomson process, been rendered comparatively easy. This has been fully demonstrated by the Standard Tool Company, of Cleveland, who are manufacturing reamers, twist-drills, taps, etc., in enormous quantities, the character-

istics of which are that only the cutting part of the tool is composed of tool-steel, while the shank is of a good grade of machinery steel. Not only is there a saving in the manufacture, but also a better product is obtained: the shank is tougher and less brittle.

Recognizing the utility of the electric process, not only for welding commercial pipe length into endless coils, but also applying the same process to locally heating sections of pipe for bending, a special company was organized, the Electric Pipe Bending Company, for making continuous coils of every description.

In making continuous circular pipe the welder is mounted on a railway truck, and, while the pipe heated in a coke-stove between welder and coiling apparatus is gradually wound up in the latter, a new piece of pipe is welded to the traveling end.

Figure 7 shows an electric transformer for heating twenty-five inches of 2-inch pipe for bending. The average daily product with one set of apparatus (one welder and one heater) is 5000 feet of 1-inch pipe, 3500 feet of 2-inch pipe bent, 3500 feet of 1-inch pipe, 2000 feet of 2-inch pipe welded and bent.

An industry owing its existence entirely to the electric-welding process is the manufacture of high-grade projectiles, carried out by the American Projectile Company. By combining the welding process with forging and hydraulic pressing, a projectile can be produced which, in price, is nearly equal to the old and unreliable cast-iron shell, and which, in quality, far surpasses the latter. Official tests have proved the shells inferior to none, while in the method of manufacture there are possibilities to still further increase their efficiency without increasing the cost. The principle involved is, briefly, to unite two forgings, representing respectively the base and point of shell, by electric welding. The point can be made of very high carbon steel, while the body and base may be ordinary machinery steel. Figure 8 shows the apparatus on which shrapnel shells are being welded.

An example of what a progressive mind will accomplish is given by the Johnson Company of Johnstown, Pa., who, under the able leadership of Mr. A. J. Moxham, have applied the electric-welding process in a manner that has almost startled its own projectors. I am not able to produce any photograph of the ponderous welding-machinery used in this work but will only give a few figures to show the magnitude of their undertaking. There are, approximately, ten welders in use, of an aggregate of 1200 horse-power. From 12 to 16 square inches are currently welded. A single weld of 48 square inches even has been produced. The product is railway-switches, crossings, frogs, chairs, special rails, splice-bars, etc. All track constructions heretofore bolted are being replaced by welded-together

rolled structures, thus furnishing an excellent wearing material, proof against being thrown out of shape by loosening of bolts or rivets. The latest application—one which has caused no end of discussion, and which is past the experimental stage—is the welding of rail sections into one continuous track for electric street-car service. Mr. Moxham has demonstrated that a continuous rail can be made, buried in the ground, and made to withstand the variations of temperature that are met with in this climate. At present he is carrying out the commercial laying of tracks electrically welded on the spot with apparatus furnished by the Thomson Electric Welding Company. Since this plant may be regarded as, in one sense, typical of the utilization of electric energy furnished from a central point to metal-working at any point within its distributing district, it may be well to briefly describe the apparatus.

Figure 9 shows the welding-train, composed of a dynamo-car, in which a continuous current of 500 volts and approximately 275 amperes is transformed into alternating currents of 300 average electromotive force and 650 amperes, which currents, after passing through an adjustable reactive coil, enter the primary of the welding transformer, suspended from a boom in the welding-car. The motor-dynamo is of peculiar construction, having only one winding. It is a regular continuous-current motor with commutator having (in a two-pole motor) two of its commutator segments 180° ~~inches~~ apart, connected with two collector-rings. It is virtually a revolving commutator, alternately connecting the two poles of the welder primary with the trolley and ground circuits in opposite directions. The efficiency of such a motor-dynamo is very high, (about 92 per cent.), and about 30 per cent. more energy can be transformed by its use, as compared with the mechanical energy that can be delivered by the pulley on armature shaft when used as a plain motor. This is because twice in each revolution there is a direct connection between welder and line, without using the armature windings.

The welder shown separately on Figure 10 has two transformers with oil insulation and can be operated with immunity from electric shocks in pouring rain. A hydraulic jack, operated by a hand-pump shown at the right, furnishes the necessary pressure. The cars are equipped with electric motors for hoisting and swinging welders, pumping water for water circulation in jaws, grinding the surface of the rail clean, and moving the cars on the track. The rails are butted against each other, and two chucks are welded from either side across the joint. These chucks are not only welded to both of the rails, but, by the lateral pressure exerted against the heated ends of the rails, force the latter into each other.

METALS, ALLOYS AND COMBINATIONS OF DIFFERENT METALS ACTUALLY WELDED BY THOMSON'S PROCESS.

METALS.

Wrought Iron	Wro't Copper	Tin	Cobalt	Aluminum	Gold (Pure)
Cast Iron	Cast Copper	Zinc	Nickel	Silver	Manganese
Malleable Iron	Lead	Antimony	Bismuth	Platinum	Magnesium

ALLOYS.

Various Grades of tool Steel	Musshet Steel	Wrought Brass	Fuse Metal	Aluminum Alloyed with Iron	Silicon Bronze
Various grades of mild Steel	Stubs Steel	Cast Brass	Type Metal	Aluminum Brass	Coin Silver
Steel Castings	Crescent Steel	Gun Metal	Solder Metal	Aluminum Bronze	Various Grades Gold
Chrome Steel	Bessemer Steel	Brass Composition	German Silver	Phos. Bronze	

COMBINATIONS.

Copper to Brass	Brass to Wr'ght Iron	Brass to Tin	Wrought Iron to Tool Steel	Wr'ght Iron to Musshet Steel	Wr'ght Iron to Nickel
Copper to Wrought Iron	Brass to Cast Iron	Brass to Mild Steel	Gold to German Silver	Wrought Iron to Stub Steel	Tin to Lead
Copper to German Silver	Tin to Zinc	Wrought Iron to Cast Iron	Gold to Silver	Wr'ght Iron to Crescent Steel	
Copper to Gold	Tin to Brass	Wrought Iron to Cast Steel	Gold to Platinum	Wrought Iron to Cast Brass	
Copper to Silver	Brass to German Silver	Wrought Iron to Mild Steel	Silver to Platinum	Wr'ght Iron to German Silver	

Experience has established the following facts: A continuous 70-pound rail requires about 150,000 pounds strength to withstand the maximum strain put upon it longitudinally by the variations in temperature from coldest winter to hottest summer. An electric weld will only break at 279,000 pounds strain. Four joints can be made in an hour, under proper conditions. The electric conductivity of the joint is as great as the rail itself. Figure 11 shows the appearance of a weld.

In concluding this article I feel that I have been unable to do justice to the subject, it being too large a one to be treated in detail in a single article. It will serve, however, to draw the attention of the engineer to the practical work accomplished, but the future possibilities are hard to predict in view of the general growth of engineering in the past.

To sum up, electric welding has these indisputable advantages:

The heat is sharply localized to the joint and metal near it.

The temperature obtained and required can be exactly regulated.

The rapidity of heating and its distribution can be controlled by simple means. Irregular forms can be welded in the desired relation of its various parts.

By this process all metals, as well as the alloys of all metals, are weldable.

The welding operation is carried on under the direct inspection of the operator.

The operation can be and often is made automatic, and the result is absolute uniformity; oxidized surfaces are excluded from the joint, and only clean metal unions made.

Pieces can be welded to exact size, and finished pieces may retain their finish during welding.

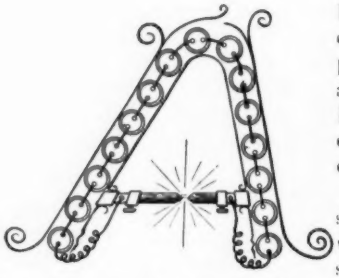
The process may be applied to pieces in place, as in track-welding. Water-power may be employed for the work, or the cheapest fuels of lowest grade.

The greatest convenience and cleanliness attends the practice of the process.

The cost of fuel is not greater and generally less than in forge-welding, while the labor is reduced one half.

BEGINNINGS AND FUTURE OF THE ARC-LAMP.

By S. M. Hamill.



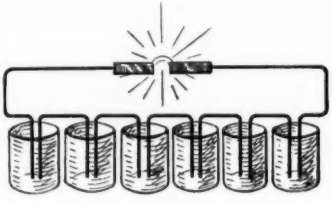
ARC-LIGHTING may properly be divided into three periods: that prior to 1876; that between 1876 and 1894; and that of the future. In 1810 Sir Humphry Davy produced an arc-light, his description of which was as follows:

"Pieces of charcoal about one-sixteenth of an inch in diameter whose ends are connected to a source of electric current, are brought near each other (within $\frac{1}{3\,2}$ or $\frac{1}{4\,0}$ part of an inch) a bright spark is produced, and by withdrawing the points from each other a constant discharge takes place through the air, producing a most brilliant ascending arch of light, broad and conical in form in the middle; hence the term 'arch light,' commonly called 'arc light.'"

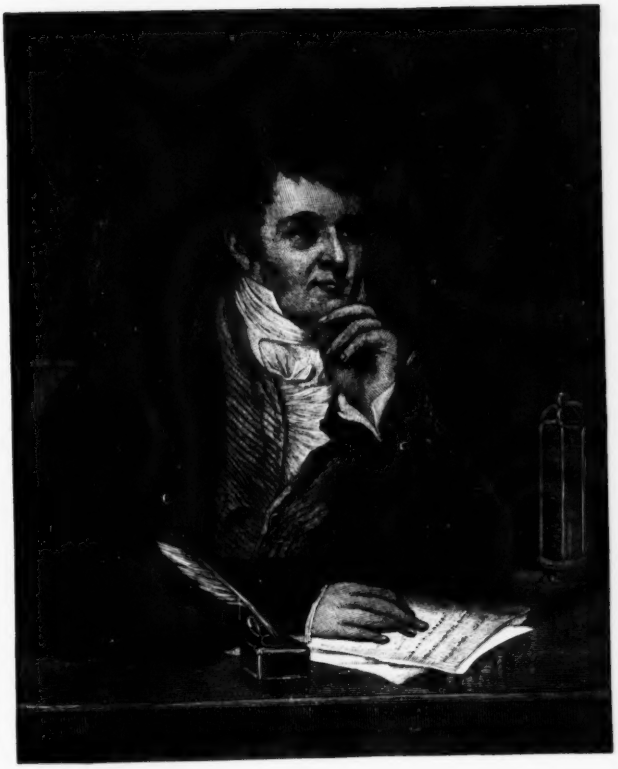
This remained an interesting laboratory experiment until the year 1844, when Leon Foucault replaced the soft charcoal with the hard carbon found in gas-retorts, and, availing himself of the use of the newly-invented battery of Professor Bunsen, succeeded in producing steady, continuous, and brilliant light.

With batteries as the only available source of electric current, commercial arc-lighting on a large scale was impossible until after Faraday's and Henry's wonderful discovery of magneto-induction. Many arc-lamps of more or less merit were invented, but, with few exceptions, they were abandoned, among the most successful ones being the Serrin and Duboscque.

Among the lamps which attracted considerable attention was the Jablochkoff candle. Owing to the unsteady working of the mechanism of laboratory lamps for feeding the carbons, Jablochkoff conceived the idea of placing the two carbons parallel to each other at a fixed distance apart, and, as with the direct current the positive carbon was consumed approx-



FIRST ARC-LIGHT.



SIR HUMPHRY DAVY.

[By courtesy of *Scribner's Magazine*.]

FARADAY SHOWING HIS EXPERIMENTS TO HIS WIFE.

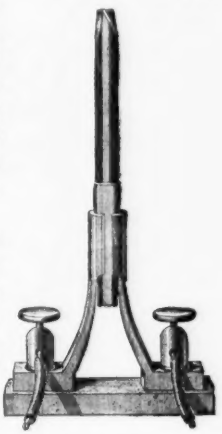
[By courtesy of *Scribner's Magazine.*]

imately twice as fast as the negative, he used an alternating current, thus overcoming this difficulty. The system itself soon became obsolete on account of the introduction of series arc-lighting.

For sixty-six years, therefore, few, if any, practical results accrued to the world from this laboratory experimenting. In 1876 hardly an arc-light was burning; not a store, factory, shop, foundry, or street was lighted by electricity. The development of arc-lighting and the kindred development of incandescent lighting and the distribution of the electric current for power are the marvels of this age of electricity into which we have just fairly entered.

PROFESSOR JOSEPH HENRY.

During the year 1876, Charles F. Brush, a young man of twenty-seven years, began his practical electrical work, the results of which aroused such wide-spread interest throughout the world, and subsequently gave such an impetus to the electric-lighting business as well as to the whole field of the distribution of power by electricity. He was fortunate in having able, energetic, and conservative business-men associated with him.



JABLOCHKOFF CANDLE.

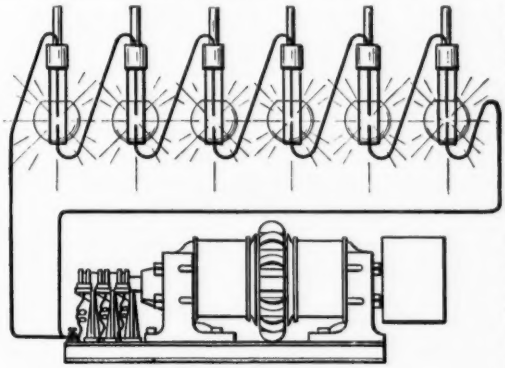
Mr. Brush, while a youth on his father's farm in Euclid township, Ohio, became greatly interested in the subject of electricity. He entered the Shaw Academy at Collamer, Ohio, at the age of thirteen. While there his first experiments with static electric machines and with electromagnets and batteries of his own construction were made. From the village blacksmith he secured old pieces of iron for use

CHARLES F. BRUSH.

in his boyish experiments. He subsequently entered the Cleveland High School, from which he was graduated with high honors in June, 1867. During his senior year the physical and chemical apparatus belonging to the school was placed in his charge. Some of the inventions in electric-lighting which he has since developed were the outgrowth of these school-boy experiments. His graduating oration on the "Conservation of Force" outlined much that has been accomplished in the past few years. After graduating from the Cleveland High School he entered the University of Michigan at Ann Arbor, from which he was graduated in 1869, one year ahead of his class, with the degree of Mining Engineer. He subsequently received the degree of Ph.D. from his alma mater.

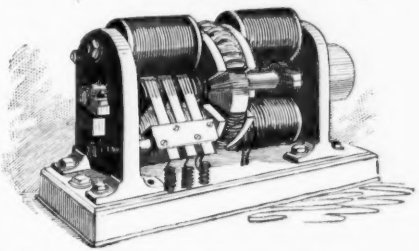
Returning to Cleveland, he organized a laboratory and conducted the business of an analytical and consulting chemist for about three years. In the spring of 1873 he entered the iron business. He still, however, even though in business, devoted a great deal of thought

and time to electrical investigations, and early in 1876 completed his first dynamo-electric machine. This dynamo was of a distinctly new type, and embodied the first of Mr. Brush's long series of brilliant investigations which have made him wealthy and famous the world over, and so perfect was it that it has never been out of order since. Either the first dynamo, or one of the very first, similar to it, was running until it was purchased quite recently for exhibition at the World's Fair in Chicago.



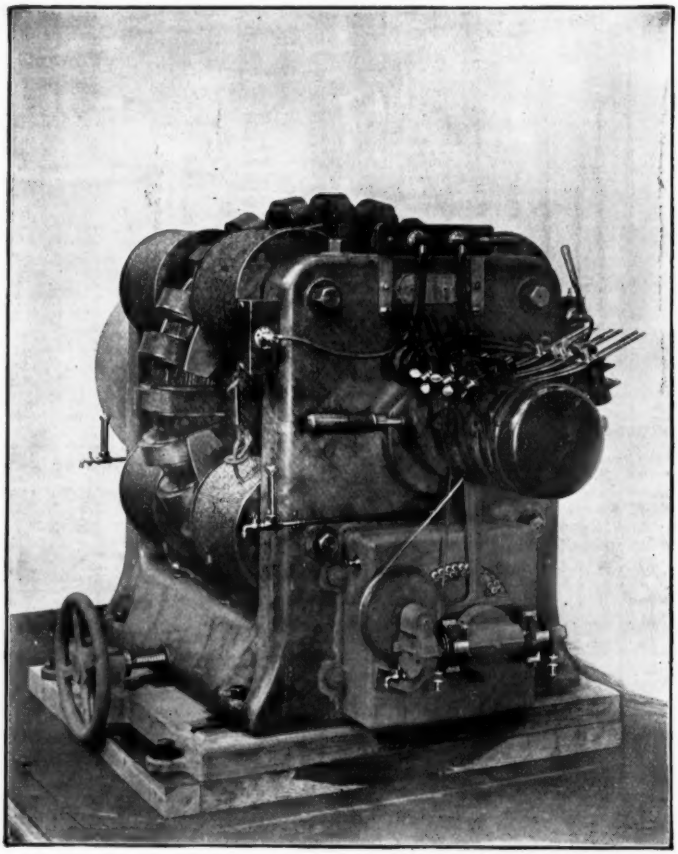
SERIES ARC-LIGHTING.

Mr. Brush's thorough knowledge of both electricity and mechanics, coupled with his ability and genius, enabled the Brush Company to make more profit from the legitimate manufacture and sale of electric-lighting apparatus than any competitor. A young man who enters the business to-day, with a thorough knowledge of electricity and with little knowledge of mechanics, is not of much value to the manager of a factory or an electric-light or -power station. The lack of knowledge of electricity on the part of mechanical engineers and of mechanics on the part of electrical engineers has been the cause of great loss to the manufacturers of electrical apparatus.



FIRST BRUSH DYNAMO, 1876.

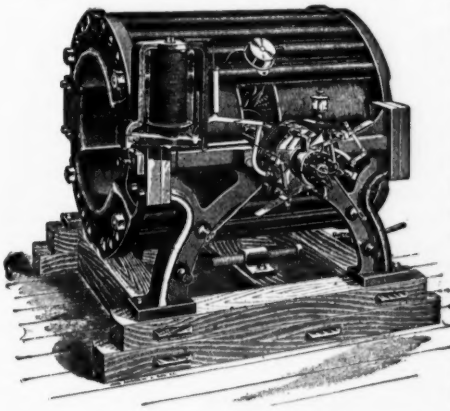
Mr. Brush experimented comparatively little. After deciding on the best methods to persue, the next step was to make a complete working drawing, with full details, ready for the pattern-maker. The whole problem had been so thoroughly worked out in his mind that in nearly every instance the first machine or piece of apparatus made from his drawings was found to be perfect in every detail and ready



150-LIGHT BRUSH ARC-DYNAMO, WITH GOVERNOR.

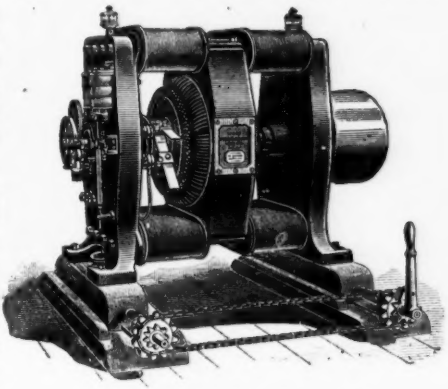
for practical use. This peculiar ability to work out and construct his apparatus on paper, and, as it were, to have a mental picture of it before it was erected in the shops, made him an ideal inventor and designer for a manufacturing company. This characteristic saved his company thousands of dollars in experimenting and enabled them to pay him in royalties upwards of $400,000 on the business of a single year.

When he first designed and constructed his arc-lighting apparatus, and the manufacture of it began on a large scale, the state of the art of dynamo- and lamp-construction was entirely undeveloped. Shop machinery and tools for the manufacture of electrical apparatus were unheard of, and it became necessary to design them for this purpose. Being an accurate and skillful draftsman and mechanic, and perfectly at home in the use of tools for both wood- and metal-working, he devoted much time to the designing and building of machinery in order to manufacture his apparatus.



THOMSON-HOUSTON ARC-DYNAMO.

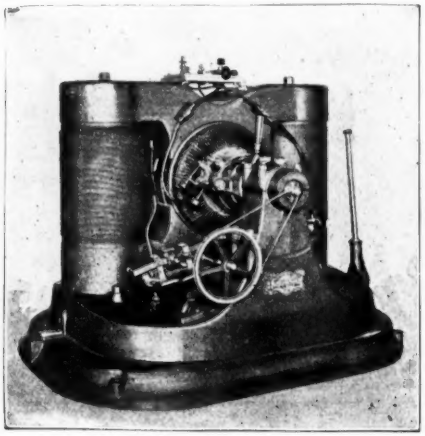
Many of the machines and tools suggested and designed by Mr. Brush are widely used throughout the world in the factories where they manufacture electrical apparatus. All the machinery, tools, and methods for making and copper-coating electric-light carbons and manufacturing storage-batteries were very largely originated by him.



FORT WAYNE (WOOD) ARC-DYNAMO.

The subject of insulation—such a vital point in modern dynamo-construction—necessarily received a great deal of his attention, and his methods are widely used to-day. The designing of dynamos and construction of machinery and tools for manufacturing them was only a small portion of the field which he had entered. The whole subject of the

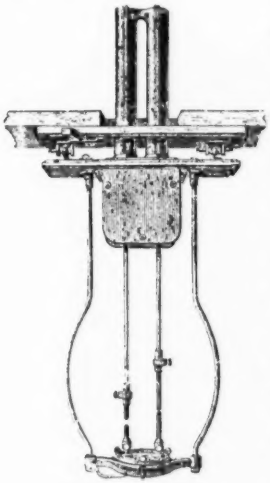
proper method of distribution of current for electric-lighting was before him. The dynamo and lamp were built, but the measuring instruments, the electric-light stations, involving questions of boilers, engines, proper construction, governing and erection, were questions to which he gave a vast amount of his time. The first electric-light stations in the world used Mr. Brush's apparatus and, necessarily, when the erection of a station was under consideration, he was consulted and his plans followed. The whole field, therefore, of the conception, designing, and construction of electric-lighting apparatus; the planning of the factory; the designing of new tools and machinery for manufacturing the new and unheard-of articles; the best methods for testing, boxing, and shipping the apparatus; the planning and laying out of the electric-light stations; the arranging of the switchboard and electric-light circuits, which were to run from the station in innumerable directions; the best methods of erecting the pole lines and lamps in order to avoid risk of fires; the best methods for insulating wires, which at that time was so difficult to secure as to lead Mr. Brush to design complete machinery for insulation in the Brush factory—were all difficult and unsolved problems, to which he gave hourly thought and attention during all the early years of the development of the business. This was done at a time when there were absolutely no precedents and no one to follow. It meant hours of toil and care; it meant work at the factory before the workmen arrived in the morning, and work in the laboratory after the day's work of others was done.



STANDARD (SPERRY) ARC-DYNAMO.

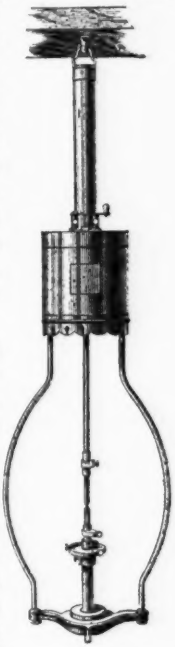
The first of the large arc-dynamos of 1893 was started in one of the large electric-light stations and has since been running regularly. The machine was built from the original windings and designs, notwithstanding that the construction of a 7000-volt constant-current arc-dynamo is one of the most difficult problems of the day in dynamo-construction, and in 1876 was considered an impossibility. These facts

indicate the characteristics of the man to whom we all in the electric-light business owe so much, and to whom is due largely the modern complete methods for the generating and distributing of the electric current for lighting.



DOUBLE ARC-LAMP.
[For Outdoor Lighting.]

When a majority of the directors of the old Telegraph Supply Company of Cleveland (subsequently the Brush Electric Company) reported to the manager that Brush was spending considerable money in trying to devise a system of electric-lighting; that they thought he was working in a field without a future and that it was better to confine themselves to their legitimate business—the manufacture of telegraph instruments and electric bells — they did not have the same conception that Mr. Brush had of the possibilities of the future. The apparatus was built and the system devised, but the problem of persuading the public to purchase and use it was unsolved. The small dynamos and lamps exhibited at the Franklin Institute, at Philadelphia, and the Mechanics' Fair, in Boston, were great advertisements.

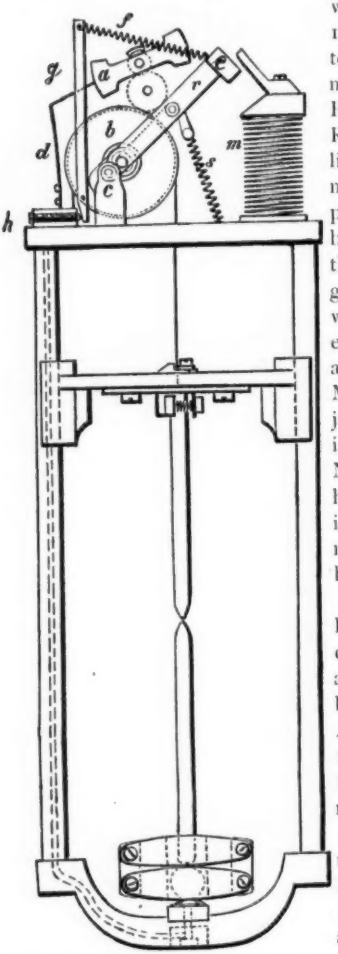


SINGLE ARC-LAMP.
[For Indoor Lighting.]

The original dynamos and lamps were sold for use in factories. The large woolen- and cotton-mills of New England became a great market. Many of these mills are lighted to-day with Brush apparatus sold prior to 1880.

The idea of the central electric-light station was of subsequent growth. The first public places lighted were those surrounding the court-house in Wabash, Indiana, and the water-tower in Chicago. The public square in Cleveland was lighted by a number of arc-lights, which replaced all the gas-jets on the square at the same cost of lighting to the city. This arrangement was one of the first, if not the first, made with any municipal authority

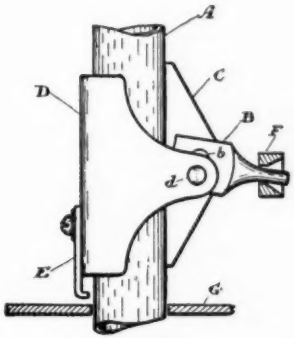
for street-lighting. The idea of a central station originated in San Francisco. One of the first electric-light companies started was organized in New York by several influential capitalists of that city, largely interested in New England mills. This was in 1879. The station was started on Christmas night of 1879 and Broadway, from Fourteenth to Thirty-fourth street, was illuminated by arc-lights. The Albany, Philadelphia, Baltimore, Boston, Rochester, and Buffalo electric-light companies, which to-day have millions of dollars invested in their plants, with thousands of lights burning nightly, were started shortly thereafter and largely by the same gentlemen and their friends. These were the first of the hundreds of electric-light stations now scattered all over the world. The city of Manila, in the Philippine islands, is just completing a station of 10,000 incandescent and 300 arc-lights. Nearly every town of over 5000 inhabitants in the United States has its electric-light station, and a large number of smaller towns are lighted by electricity.



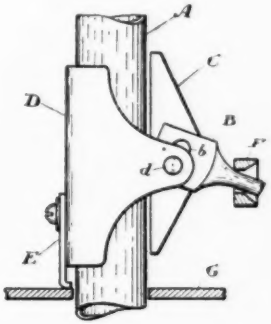
SIEMENS & HALSKE RATCHET ARC-LAMP.
[Ribbon-Feed Type.]

One manufacturing company has produced in its factory upwards of 150,000 arc-lamps and 5000 arc-dynamos. These lamps are burning all over the world. Another company has manufactured 100,000 lamps. Four hundred thousand arc-lamps is a fair estimate of those burning to-day.

Only a few years ago there was not an electrical engineering school in the country. During this year 1500 young men will be graduated from the electrical engineering schools, equipped for the business.



[Fig. 1.]



[Fig. 2.]

RECENT CONSTANT-CURRENT LAMP OF THE CLUTCH TYPE.

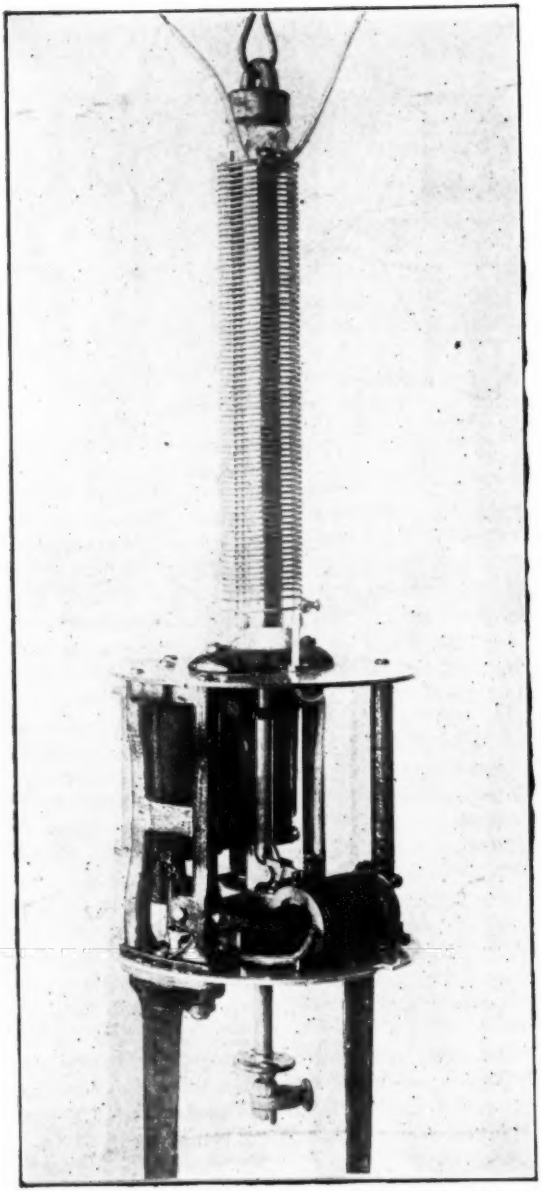
In 1883 the Brush factory turned out 5,000,000 carbons, and in 1893, 26,000,000. Prior to 1883 carbons were sold at from $70 to $80 per thousand, and in 1893 at from $10 to $12 per thousand. The National Carbon Company are just completing a factory in Cleveland, composed of fourteen large buildings, covering seventeen acres, practically under one roof. This factory is for the sole purpose of manufacturing carbons, and it has a capacity of 2,500,000,000 per year.

Shortly after Mr. Brush became interested in the electric-lighting field, many others also began their practical electrical work, among them being Elihu Thomson, Edward Weston, Hochhausen, Houston, Wood, and others in America, and Siemens and others in Europe, who produced systems of more or less merit. These various dynamos and lamps have generally been named after their designers.

The different methods of the construction of arc-dynamos is an interesting study. Scores of electricians have, with the aid of the draftsman, pattern-maker, and the paint pot, made their various dynamos appear as different as day is from night.

To build an arc-dynamo that will produce currents of electricity is not difficult, but to design a dynamo highly efficient, mechanically perfect, thoroughly ventilated, easily repaired, absolutely self-regulating, with careful regard to economy in material and labor is another problem.

Most armatures, and, therefore, perhaps most dynamos, are of the Siemens, Gramme, or Brush type, whether they be the toy dynamo for a Christmas present to the young, or the great dynamos such as were used at the World's Fair or are being constructed for Niagara Falls. The dynamos invented by Mr. Brush and Messrs. Thomson



MECHANISM OF RECENT CONSTANT-POTENTIAL ARC-LAMP.

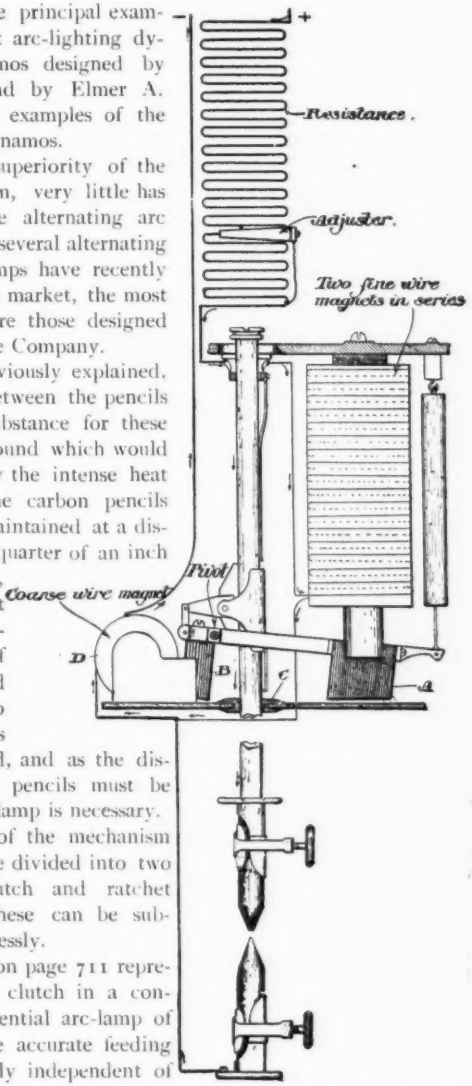
and Houston are the principal examples of open circuit arc-lighting dynamos. The dynamos designed by James J. Wood and by Elmer A. Sperry are notable examples of the closed-circuit arc-dynamos.

Owing to the superiority of the direct-current system, very little has been done with the alternating arc system. However, several alternating arc-dynamos and lamps have recently been placed on the market, the most notable of which are those designed by the Westinghouse Company.

As has been previously explained, the arc is formed between the pencils of carbon. If a substance for these pencils could be found which would not be consumed by the intense heat of the arc, and the carbon pencils could always be maintained at a distance of about one-quarter of an inch from each other, then the somewhat delicate and complicated mechanism of an arc-lamp would be unnecessary. No such substance has as yet been discovered, and as the distance between the pencils must be maintained, an arc-lamp is necessary.

The principles of the mechanism of arc-lamps may be divided into two general classes, clutch and ratchet feed-lamps, and these can be subdivided almost endlessly.

The two figures on page 711 represent a very modern clutch in a constant-current or potential arc-lamp of the clutch type, the accurate feeding of which is entirely independent of the cleanliness of the carbon rods.



CONSTANT-POTENTIAL ARC-LAMP.

ELECTRIC SEARCH-LIGHT.

This result is accomplished by not allowing the rod *A* to slide, but by gripping it (Figures 1 and 2) and holding on until the trip *E* reaches its lowest position on *G*, when it suddenly releases and takes hold further up. This action is so rapid as not to affect the steadiness of the light, an air dash pot preventing any sudden movement in a downward direction.

The improvements in instruments and switchboards for stations have been very great and the most modern are not only ornamental, but have reached a very high degree of perfecion.

The future of the arc-light is secure. To state more than this is speculation. What the younger Brushes, Thomsons, and Edisons will accomplish cannot be definitely stated. Probably for a few years it will be along the line of improvements in present methods and machinery, after which genius may present us with new and astonishing changes.

The arc-dynamo will be made in larger units. A growing opposition to overhead wires leads central-station men to increase the number of lamps on each of their already existing circuits. The high rate has a like tendency for rental of underground conduits. A few years ago a dynamo of a capacity of ten amperes and fifteen hundred volts (thirty arc-lights) was considered a wonder and dangerous. To-

day many are running of the capacity of ten amperes and seven thousand volts (one hundred and fifty lights). The whole tendency, not only in arc-lighting, but in the distribution of power, is toward larger machinery and higher potential. The arc-lamp itself will be simplified and beautified, but its general construction will change little.

As in the past, the engine- and boiler-manufacturers will do their part in the improvements of their engines and boilers along the line of lower cost of manufacture and in higher efficiency. Central-station managers will do their portion in accomplishing improvements by demanding from the manufacturers cheaper, larger, better, more economical, and more efficient apparatus.

The great problem for the future lies in the management of local electric-light companies. In these modern times, it is little we care for glory. Dividends are the cry of the hour. How to earn them is the problem. There are in this country three large arc-light stations under one management in a city of 500,000 inhabitants, earning from 12 to 15 per cent. on the actual cost invested. An electric-light station in another town of 12,000 people earns about the same. Both of these companies are operating under ordinary conditions. A company in a city of 40,000 inhabitants, using certain machinery, with a valuable city lighting contract, lost money and failed. Another company, with the same machinery, but under different and very conservative and economical management and with a much lower contract for lighting with the city, earns from 15 to 20 per cent. on the actual investment. A company in a town of 5000 people became bankrupt and was sold at a receiver's sale. New management, practically under the same conditions, earned satisfactory dividends for the stockholders.

These examples would indicate that there is large remuneration from such investments, notwithstanding the fact that a large number of electric-light companies in the country have lost money. It is not so much a question of engines and boilers and dynamos and lamps, as of management. It is not so much a question of cheap machinery as of management.

Cleanliness in a station and on the circuits is essential. Dirt, grease, and filth scattered about are a sure indication of running behindhand. A neat station, dynamos, and lamps and engines and boilers, always clean and in good order, the poles and circuits well kept up, uniform rates of lighting, based on a fair margin of profit, a good and regular light every moment of the year, courteous and fair treatment to customers, insure success and dividends.

Arc-lighting as a business has been developing for eighteen years; incandescent lighting for thirteen years; and the distribution of power for stationary and street-railway motors for nine years. The future

development of the distribution of the electric current for incandescent lighting and power and for heating will be almost beyond comprehension. However, this does not prove that the arc-light has seen its best day and that its use will decrease. On the contrary, there will be more arc-lamps sold during the next fifteen years than during the past fifteen years. The arc-light is preferable for lighting large areas. Its field is in the factory, in large stores, and in our streets.

The arc-lighting of city streets is in its infancy. New York has 2750 2000-candle-power street lights; 6000 would hardly light the city. Brooklyn has 2200 lights; it will require 3000. Chicago has 1300: 7000 are needed. Buffalo has 2000 and requires 4000. Boston will shortly have 2300 and should have twice as many. The city of Cleveland has 245: 3000 will be insufficient. The city of Detroit has just purchased 1500 arc-lamps as a starter for lighting the whole city by electricity; they will need twice as many within a year or two. Comparatively little street arc-lighting is done in the large cities and towns. Ten times as many arc-lights will be used in two or three years, for street lighting, as are used to-day.

Street gas-lamp posts and the oil-lamp posts must go. They have outlived their usefulness. They are to the arc-lamp as the moon is to the sun. Our streets are lighted purely for safety and convenience. The powerful and penetrating rays of the arc-light tend to lessen crime. The future, therefore, of the arc-light is not an uncertainty, although in comparison with the growth and development of its younger sisters and brothers, much less will be heard about it, but more will be seen by it.

THEATER-BUILDING FOR AMERICAN CITIES.

By Dankmar Adler.

FIRST PAPER.

OCCASIONALLY a theater is so constructed that the eye and ear of every person in the audience can easily follow the performance on its stage; that its means of ingress and egress and of internal communication are easy and commodious; its ventilation such, that the air does not become pestilential before the close of each performance, and its decorative treatment neither vulgar nor tawdry. The designer of such a house is thought to have accomplished a most remarkable and noteworthy feat, and architects and laymen join in expressing doubts of the possibility of repeating so unusual and unexpected a success.

It is my good fortune to have been the architect of several successful theaters and public halls, and to be among those who have experienced the treatment above indicated; and yet I feel myself justified in maintaining that success in theater building is no more difficult of achievement than in any other branch of architectural practice, provided one's action is based, not merely upon recorded precedent and tradition, but also upon extensive and careful original observation and independent thought. For these reasons I shall not make this article a repository of historical information about the theaters of the past, nor a description or critical disquisition upon the theaters of the present day, nor yet a compendium of scientific formulæ for solving the various problems of theater-design. With a view to stimulating original and independent thought and action, I shall call attention to certain facts and conclusions, the recognition and formulation of which are within the reach of every intelligent observer and of every industrious student of objects and events.

If every theater-goer could build his own theater, theater-building would have become as familiar and as easy of successful accomplishment as house-building, and the mental processes of the theater designer which determine success or failure would no longer be regarded as occult and mysterious. But theaters are comparatively few in number, and while each theater counts its patrons by the thousands, only few of these can ever have a personal financial interest in or influence upon its erection or management, or become acquainted with the details of its construction, equipment, and operation. Therefore, public opinion upon theater plan and construction has never been clarified or crystalized, and theaters have been and probable will be constructed

rather as the embodiment of the views of a very few immediately interested parties than as expressing the wishes of the great theater-going public.

The architect can hardly be expected to ascertain by direct intercourse with each individual theater-goer what the public really demands of its theaters: but he has opportunities for observing the conduct of the mass of the people toward theaters, and of deducing from this conduct what the people want. Upon taking note of the relations of the theater-going public in the cities where there are many theaters between which to choose, the first impression forced upon the observer is, that the public will go into any house which presents upon its stage a sufficiently potent attraction. No matter if the house be a notorious fire-trap; no matter how steep and incommodious the stairs leading to the different parts of the auditorium; no matter how narrow the aisles; no matter how promotive of torture the positions into which form and arrangement of seats force their occupants: no matter how vile its odors; no matter if the acoustic qualities of the auditorium are such that only by the most constant and close attention is it possible to follow the words of the play: no matter how vulgar and tawdry or how weak and expressionless the decorative treatment of the house,—if a well-known and popular attraction is presented upon the stage, it will play to crowded houses. On the other hand, theaters and opera houses in which the construction and equipment are most thorough, and in which the utmost regard has been paid to the comfort and safety of every member of the audience are not filled unless the attraction upon the stage is of the first quality, while inferior attractions will always play to empty benches.

In America theaters are not considered, as in continental Europe, quasi-educational institutions maintained by state and municipal governments: but almost invariably they are ventures for pecuniary gain, and the purpose which governs their projectors, owners, and managers, to which the architect must necessarily subordinate himself, is apt to be that of drawing to their seats the greatest possible number of people with the smallest possible outlay for construction, equipment, and maintenance.

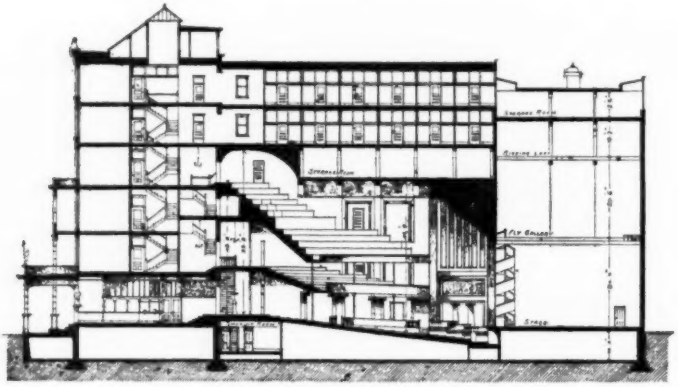
But fortunately the conditions of competition are often such that broader selfishness sees in a liberal, sometimes even in a lavish, outlay, the means for obtaining returns proportionately greater than those following a parsimonious policy. It may be safely assumed that if the public will attend in large numbers to see a fine play well rendered in an ill-constructed theater, still larger numbers will flock to well-constructed and well-equipped theaters to see the same kind of performance.

As box-office receipts indicate that the interest of the theater-

going public centers in the stage performance, the architect of a theater will first concentrate his attention upon the stage and its adaptation to the productions to be presented. Next in order would come the effort to eliminate from the design of the auditorium everything which tends to restrict the full enjoyment by the audience of the stage performance, and the development of everything which tends to add to that enjoyment. Ease and convenience of approach are probably next among the good qualities of a theater which are recognized by the public, while solidity of construction and limitation of danger by fire are apparently the last points of superiority appreciated by the public, and therefore most often ignored by owners and managers.

I shall endeavor to sketch the lines of development which should be followed in designing the average American theater, built for the purpose of earning a reasonable interest upon its cost, and managed upon the lines prescribed by a broad business policy, which seeks not only to cater to the expressed wishes of existing patrons, but endeavors continually to increase their number by striving to learn whether the public may not have latent wants and wishes as yet unexpressed and undiscovered, by catering to which the management may derive further profits.

It is natural to assume that the larger and better equipped the stage the better will be the performances upon it, and therefore the greater the drawing power. But it may also be claimed, that a larger auditorium will accommodate larger audiences and consequently will have greater box-office receipts. There is no rule for determining the happy mean between these two views. We are, however, safe in assuming that for the production of anything except grand opera and great spectacular performances, it is not well to have the auditorium too large ; and that a house containing from 1200 to 1500 seats will be more satisfactory than a larger one ; further that when its seating capacity exceeds 1800, it will have but little value as a place for rendering comedy, drama or light opera. A certain intimacy of relationship between the actor and the spectator is essential in all the lighter forms of stage production ; and the ability, not merely to hear what is said or sung, but also to follow closely the facial expressions and gestures of the actors, is a necessary condition to the enjoyment of plays of every kind, except only the purely spectacular or the purely musical, or combinations of the two. Besides, very many people hear partly with their eyes ; that is, they unconsciously follow labial movements and facial expressions as interpreters of the meaning of the sound waves which strike their ears. Therefore a large majority of the audience should be near the stage, which can hardly be the case in a theater containing more than 1500 seats, while one with as many as 1800 seats is very near the danger line.



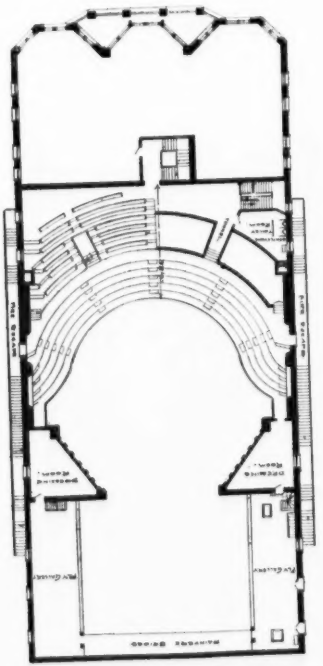
M'VICKER'S THEATER, CHICAGO.
[Longitudinal Section.]

Stage mechanism and lighting are subjects each of which would require for exhaustive treatment several articles of the length of this one. It may be said that the ingenuity and fertility of rescource displayed by the modern American stage carpenter have earned our unbounded admiration and entitle him to the deferential regard of every architect. Large stores of valuable information can be gleaned by the architect from free conversational intercourse with representative men in that craft and should be intelligently utilized in his work.

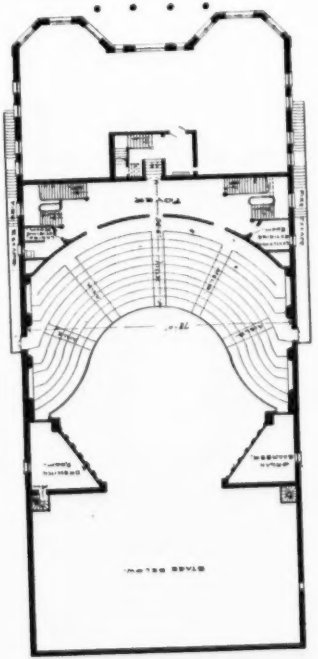
The motto of the architect designing the lighting apparatus of the stage should be in the words of the dying Goethe, "More light." No stage was ever too brilliantly lighted. But while brilliant illumination is essential, the uniform and general diffusion of light and the means for its graduation and control are of equal importance, and must be carefully studied and conscientiously designed.

It is generally difficult in American theaters to provide sufficient space for carpenter-shop, scene-painters' atelier, for work-shops for the manufacture and repair of properties, costumes, etc., etc. Space is almost always considered too valuable, and these very important processes are often carried on altogether outside of the theater, or, if in the theater, in dark and inaccessible places. The intelligent architect will in all cases make an effort to give due attention to the requirements of this part of the service when he begins to plan a theater.

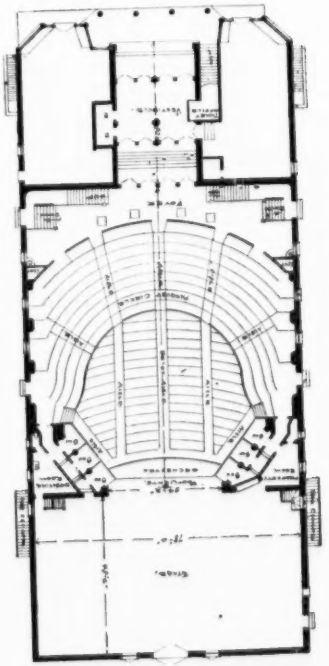
If good service is to be rendered by the orchestra, ample provision should be made for its seating, and there should also be a well-ventilated room available for the storage of instruments, sheet music, and the wraps of the performers.



[Plan of Main Floor]



[Plan of Balcony.]



[Plan of second Balcony.]

M'VICKER'S THEATER, CHICAGO.

Every one within the walls of the theater wishes to see and hear what is being presented on the stage. As has been before stated, seeing is part of the act of hearing. If the seats are all so arranged and disposed, that their occupants can *see* the entire action upon the stage, it will go a long way toward enabling them to *hear* the accompanying words.

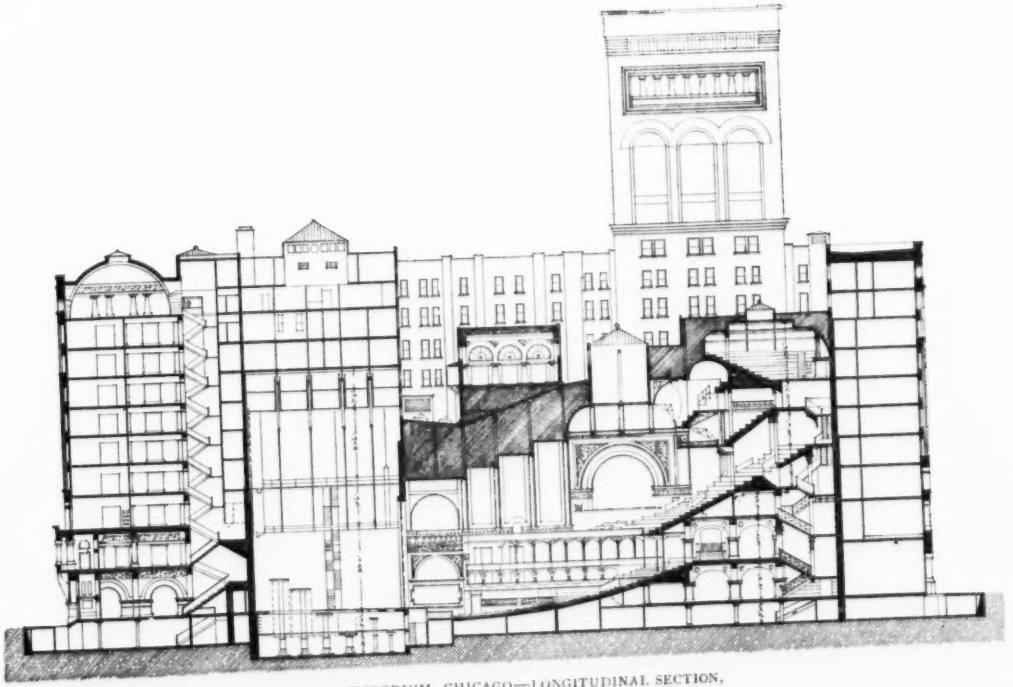
Following the principle of Scott Russell's well known isacoustic curve, but using the stage floor at or near the curtain line as the center to which the lines which determine the curve are drawn, there will result a banking of seats which gives spectators a good view of the entire stage. In working out this curve, the rise of the seats may become steeper than is compatible with fixed conditions as found in some houses. In such cases it becomes necessary to make adaptations which bring the total rise within the available limits of space. Drawing the sight lines over every second head, instead of over every head, is one of the possible modifications and as an auxiliary to this expedient for reducing the rise of the banks, as also setting the seats alternately behind each other, so that each spectator sees between and not over the heads of those immediately before him.

It is necessary in constructing the seat curve, to remember that people wish to see the sides of the stage as well as the center, and that therefore the spectator must also be given good sight lines on diagonals drawn to both front corners of the stage.

Having placed our audience in position as favorable for seeing the stage and all that is upon it as limiting circumstances and conditions allow, and remembering that lines approximating those of the isacoustic curve allow free and unobstructed progress of the sound waves from the mouths of the actors to the ears of the audience, it remains only to so construct the walls and ceilings of the auditorium that they may act as conservators and transmitters of the the sound waves originated by actors, singers, and orchestra, and to avoid the use of contours and materials which are apt to injure the quality of the sound.

The general theory of the conservation and transmission of sound waves may be stated as follows:

The sound waves, produced in the open air, travel very much as do the ripples in a pool when a stone is thrown into it, but the form of the ripples produced by the act of speaking or singing is ovoid rather than circular, the longitudinal axis of the ovoid corresponding with the direction toward which the speaker is facing. As in the case of the ripples in the pool, the sound waves grow smaller in size and in force until the sum of the friction and inertia encountered becomes equivalent to the original impulse. Therefore in the open air, unless the wind favors, the human voice in ordinary tones will

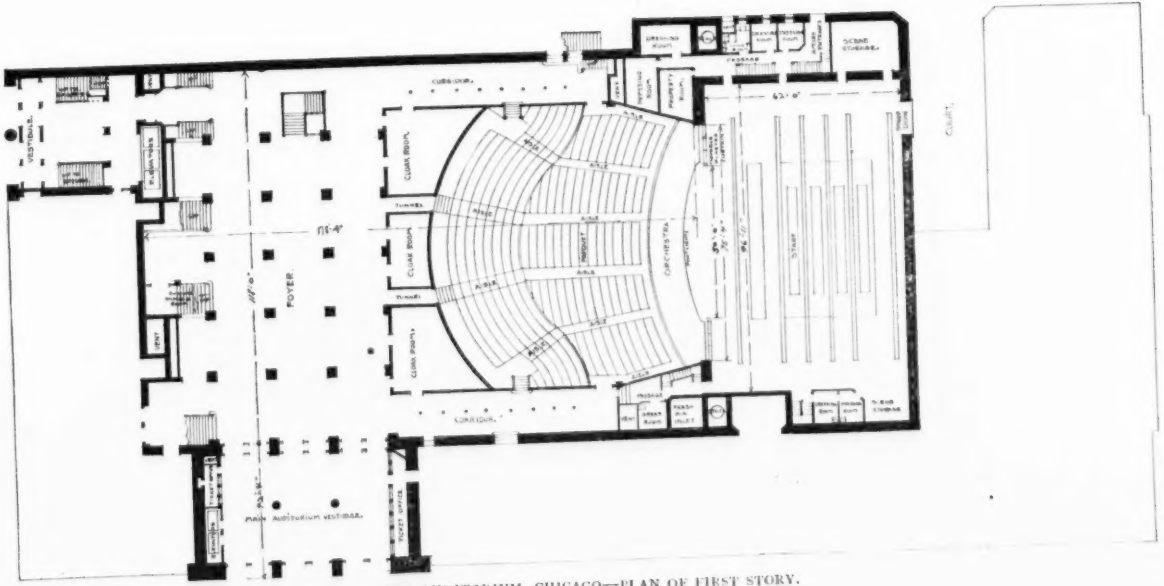


THE AUDITORIUM, CHICAGO—LONGITUDINAL SECTION.

not carry very far. On the other hand, if sounds are projected into the mouth piece of a speaking tube, the waves can travel in one direction only, and those which would in the open air travel in all other directions are forced to travel forward, and thus the original impulse in the direction of length of tube is intensified and the distance to which the sounds carry is greatly increased. A more forcible illustration of the same principle is found in the trumpet. The breath, which blown directly into the air through the puckered lips will produce but a very faint sound, audible only to a distance of but a few feet, will carry thousands of feet when projected through the trumpet. So also if the sounds produced upon the stage are, as in the trumpet or as in the speaking tube, held together at the proscenium opening, and are not permitted to diffuse themselves in any direction excepting that of the audience,—if the wall surfaces and the ceiling are so formed as to hold in the sounds, and to carry and deflect them to the ears of the audience,—then a greater number of people can hear distinctly in the same room than under any other conditions.

The practical application of this principle gives an auditorium approximately fan shaped in plan and cuts off a number of front side seats from which but an unsatisfactory view of the stage can be obtained. But the effort to conserve the sound waves influences to a still greater extent the vertical dimensions of the auditorium. The proscenium must be low, not a foot higher than is necessary to permit full view of any possible grouping at the back of the stage from the last and highest seat in the house. If the proscenium is made higher, so much more air will have to be unnecessarily set in motion, that needlessly great efforts of speakers and singers are required if their voices are to fill the house and to reach every member of the audience. The necessity for giving reasonable headroom over balconies and galleries brings with it a gradual increase in height of ceiling from the proscenium outward. This upward tendency of the ceiling lines should be modulated into a profile which deflects the sound waves downward toward the rear of the lower portion of the house.

But if the wall and ceiling surfaces, although otherwise constructed upon correct lines, are left smooth and unbroken, particularly in very large rooms or in rooms having no galleries, a certain rolling or reverberation is found to be the accompaniment of every sound produced within their walls. For by friction, and to some extent by sympathetic vibrations, the enclosing surfaces of a room affect the progress of the sound waves nearest them in such manner, that in both rhythm and velocity they differ from those which pass directly through the body of the air. These differences are cumulative, they become greater as the area of smooth and unbroken enclosing surfaces increases, and they



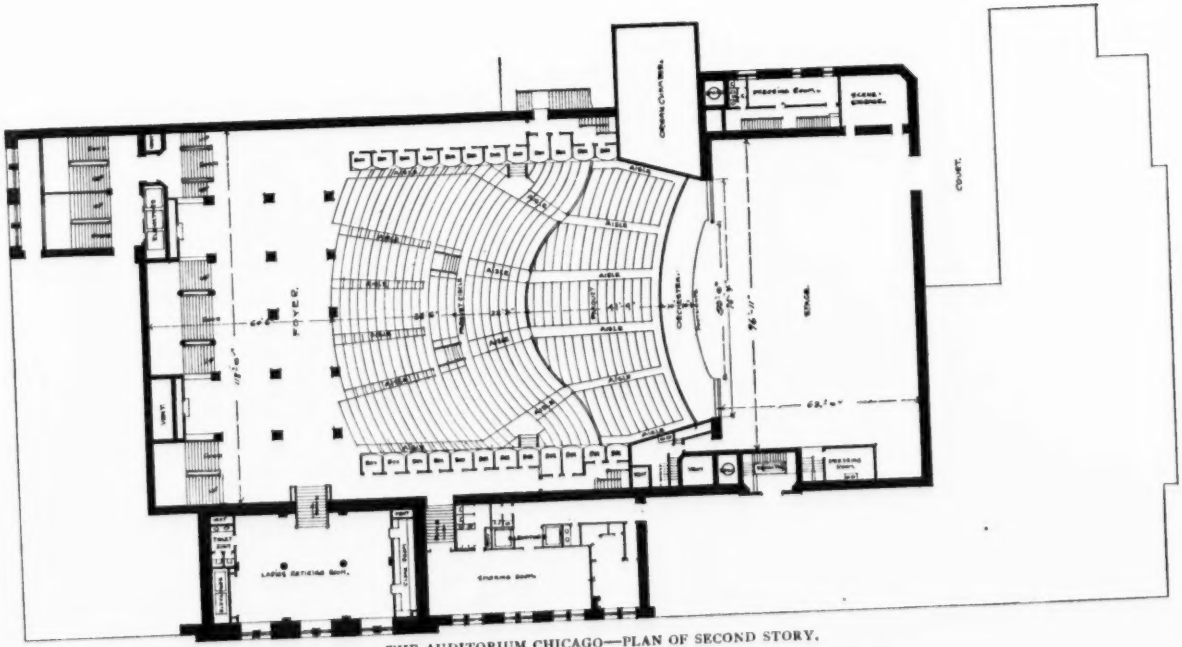
THE AUDITORIUM, CHICAGO—PLAN OF FIRST STORY.

finally assume such proportions as to cause confused murmurings and reverberations, which are in direct proportion to the extent to which a cumulative increase of variations in rhythm and speed of sound waves has been permitted to develop itself. Therefore if the enclosing surfaces of an auditorium are broken by artificial means, such as the introduction of galleries, pillars, pilasters, arches, beams, coffers, panels, etc., etc., those sound waves whose line of movement is along the wall and ceiling surfaces cannot make much progress before they meet obstructions and are deflected into the body of the house ere they have had time to attain a velocity or rhythm sufficiently at variance with that of the sound waves moving directly through the air to distress the auditory nerve. Similar means will prevent the formation of a positive echo, which indeed is only found in rooms with comparatively level floors, and with high, smooth walls unbroken by galleries.

A certain unsympathetic harshness of sound which sometimes culminates in a hard rattling reverberation is found characteristic of halls, the enclosing surfaces of which are formed of very hard and rigid materials. This difficulty is not encountered if walls and ceilings are faced with resonant materials and when these are given a certain degree of freedom for vibrating in sympathy and harmony with the sound waves. But this resonance and sympathy are apt to become troublesome in an empty or partly filled house, although they are almost always toned down in a full house. Just where to draw the line between sufficient and excessive resonance is a most difficult and perplexing problem which constitutes another reason for the practice before recommended, of not making a house much larger than is necessary for the accommodation of its average audiences.

Again, the purpose of bringing a large portion of the audience near the stage and into close proximity with the actors, is more easily attained in a wide and shallow house than in one which is narrow and long. But a house may be so broad that the number of extreme side seats from which but an imperfect view of one-half of the stage can be obtained becomes too great, thus forming a limitation to excessive lateral development of the auditorium.

An audience which would be almost lost in a theater seating 1800 or more persons, makes a very respectable showing of numbers in a house having 1500 or 1200 seats. The individual members of a moderate audience in a small house will have a sense of nearness and sociability conducive to enjoyment, while the same number of persons in a large auditorium will feel lonely, chilled, and out of place. The former will spread reports of having spent an agreeable evening at a pleasant performance, while the latter are apt to report dismal failure. It is easy to imagine the effect of such reports upon the box-office re-



THE AUDITORIUM CHICAGO—PLAN OF SECOND STORY.

ceipts. Again, people always want that which is difficult to get. Where the seating capacity of a house is very great, it is more difficult to make advance sales of season tickets, and thereby obtain a preliminary guarantee fund for the success of any particular line of performance. It happens more rarely that large houses are sold out—the stimulus of a consciousness that seats are difficult to get is wanting—all of which is in favor of a house of but moderate seating capacity.

The ideal stage is large. The stage of the Grand Opera House at Paris and of the Imperial Opera House at Vienna is each larger than any theater in America,—stage, auditorium, and lobbies included. But their magnificent proportions are but rarely called into full use. I have seen upon the stages of these opera houses renditions of such operas as "Le Prophete," "Tannhaüser," "Lohengrin," and "Flying Dutchman," in each of which there would have been opportunities for scenic displays or for processions, marches, and ballets, whose effectiveness would have been much enhanced by utilization of the great resources afforded by the enormous dimensions of the stages of these great houses. But in each case the setting was confined to a depth of stage little, if any, greater than that used for the same production in the Metropolitan or the Auditorium. I have also seen performances upon the stages of smaller European houses, such as the Municipal Opera Houses at Frankfort and at Halle, the Lessing Theater at Berlin, and have found in every instance stage settings which brought their working dimensions down to those of the stage of the ordinary American theater of the better class.

In the largest American cities long seasons of grand opera are given with an ensemble comprising a small army of people and with great splendor of scenery and costumes, requiring correspondingly large stages, of which each city where such performances are possible has one or more. There is no likelihood of so great and rapid an increase in wealth and population of these cities that the number of houses of this type will have to be increased in the near future. Grand spectacular performances are organized for the purpose of utilizing these exceptionally large stages in the intervals between seasons of grand opera. But when the great operatic companies, or the companies which have given grand spectacular displays in such houses as the Metropolitan and the Auditorium, start upon their travels, they go in light marching order; the number of principals is diminished; chorus, ballet, orchestra, are all reduced to the smallest possible dimensions; the grandeur and splendor of the scenic effects are cut down; everything is adapted to the economics of railway transportation. Shorter seasons and smaller audiences are expected in the smaller cities which they may see fit to visit, and as these visits are compara-

tively few in number and short in duration, there is no necessity for building in the smaller cities stages of dimensions rivaling those of the great houses of New York, Chicago, Boston, Philadelphia, and St. Louis. Again, in the larger cities almost every theater is built and maintained chiefly for a certain special line of attractions to which its stage is adapted. The great expense incident to the maintenance of very large companies and to the production of spectacular performances upon a very large scale limits their number and confines their rendition to the few large houses already in existence. So that the theaters which are likely to be built in the near future will probably be devoted to a lighter class of performance, which can be given with a smaller number of people, and with stage settings less ambitious as to size and lacking the splendor derived from magnificent dimensions. In fact, the tendency seems to be toward the organization of companies having a few members of preëminent ability, with a support as efficient as the probable financial returns of the venture may seem to permit; and this selection of individual performers of higher grade also tends to diminution of their number. In the same way, the desire for richness and sumptuousness of stage setting can be gratified more readily within a small compass than upon a stage of very large proportions. Theaters in the smaller cities are not apt to be devoted to specialties, but each must be prepared to receive upon its stage operas, spectacles, dramas, comedies, farces,—everything that is produced by the traveling companies which find it advantageous to play within their walls. The difficulty and expense of transportation are such as to curtail the personnel of even these companies, and to confine the dimensions of their scenery, etc., within the limits of a stage of moderate size.

The proscenium opening of theaters is often made so large, that it must be artificially diminished in width by the insertion of imitation draperies or of bits of set scenery, for if the stage settings were made for the full width of these excessive openings, the number of people and properties and the volume of light required would exceed the means of most companies. Probably 30 feet of proscenium opening will be found ample for all theaters less than 70 feet in width between walls, and a proscenium opening from 45 to 50 feet in width will accommodate the most elaborate spectacles ever presented in this country. The proscenium openings of the Auditorium, of the Metropolitan, of the Academies in New York and Philadelphia, and that of the Boston Theater are near these figures. It is therefore not at all likely, that a proscenium opening of more than 40 feet will be required for any theater other than the preëminently large ones before enumerated.

In the matter of depth of stage, it would seem that it is almost impossible to give effective rendering even to parlor comedy on a stage

of less depth than 25 feet, and that 40 or even 50 feet would not be an excessive depth, or one involving uneconomic results for a theater devoted to miscellaneous performances. With reference to this matter it must be borne in mind that, for the purposes of any performance, it is much easier to cut off part of the depth of the stage by means of suitable drops, than it is to add to its depth if the stage is built too shallow in the first place, and it will always be safe, in designing a theater, to take for increase of depth of stage all the space not absolutely necessary for other purposes.

In the same way it is very desirable to have as much space as possible on each side of the proscenium opening. In the absence of large assembly rooms for actors, for chorus, ballets, supers, etc., that part of the stage which is invisible to the audience can very conveniently be used for forming processions, marches, etc., and for so assembling the various people engaged in a performance as to enable them to appear promptly upon the scene. Part of this space may also be utilized for the storage of scenery, of properties, and of the baggage of traveling companies.

The height of the stage is another dimension which can hardly be made too great. Sixty or 70 feet from the stage floor to the rigging loft is not at all excessive, and 80 or 90 feet or more has been used to very good advantage. It is very desirable that it should be possible to lift the largest drops bodily without folding or rolling, and this can only be accomplished when there is abundant height.

In the design of an American theater the facilities for handling the baggage of traveling companies must not be overlooked. The quantity of baggage, consisting of scenery, properties, costumes, musical instruments, etc., carried by many traveling companies is quite astonishing to the uninitiated. It frequently happens that all this must be taken into the house late of an afternoon, prepared for a play in the evening, and removed and packed ready for an early train on the morning following the last performance.

The matter of dressing-rooms is one which well merits attention and study. It should be remembered that the more comfortable the artists who are to appear upon the stage can be made in the dressing-rooms, and the more direct and commodious the means of communication between dressing-rooms and stage, the better will be their condition for pleasing the audience.

ELECTRICITY

Conducted by Franklin L. Pope.

IT has been a matter of much regret among electrical engineers that the manufacturing company which constructed and operated the Intramural electric railway at the World's Fair, last year, has not seen fit to make public a detailed account of the results of its operation. Of course the right of the company to reserve the information thus gained for its own benefit, instead of sharing it with the public and with its business competitors, cannot be questioned, and we do not wish to be understood as criticising its action in the matter. But in spite of the official reticence as to the facts and figures of the working of the Intramural, some information of value has transpired from time to time. In a discussion in the Western Railway Club respecting the present utility of electric motors on railroads, Mr. Baker, who had general charge of the Intramural road during the fair, said that the motor-cars used enabled the work to be done with a weight on the track of only about 80 per cent. of that which would have been necessary with independent locomotives, whether electrical or steam. He observed that four motors made a very economical arrangement, because, with all the motors in series, at one-fourth the normal speed, the motors are working at maximum efficiency within a few seconds after starting. The average speed attained was about ten miles per hour, but would have been much higher but for the excessive curvature of the line. With a straight track this speed might easily have been doubled. The average number of passengers carried was a little over 33 per train-mile, though in October it averaged over 50. The average on the Manhattan system in New York is about 24 per train-mile. The total expense of fuel during the month of August was 4.3 cents per train-mile. Four cars were ordinarily run in each train, one of these being the motor-car. The latter weighed about 26,000 pounds, which, with 20,000 pounds for the motor and attachments, and 14,000 pounds of passengers, made about 60,000 pounds, giving substantially the same traction as a 30-ton locomotive.

IN the course of the discussion referred to, it was pointed out that the cost of fuel on the Intramural road, as given by Mr. Baker, was about 4 cents per train-mile on a 50-ton or 60-ton train, while on a steam-railroad the same expenditure of fuel would haul a 500-ton freight-train at the same speed, indicating that modern locomotives are doing about eight times as much work as the electric locomotive with the same fuel. It was stated by an expert present that a horse-power-hour can be generated in a modern locomotive by the evaporation of from 25 to 28 pounds of water, and that in average service from 5 1/2 to 6 pounds of water could be evaporated for each pound of coal. One member remarked that the figures presented at the National Electric Light Convention, showing the average amount of power generated at the principal electric-light and -power stations of the country in proportion to the amount of coal consumed, were so low that he would be ashamed to acknowledge them as an average for locomotive performance. The performance of the Metropolitan electric railway of Chicago, which is to go into operation this fall with electric motors, may be expected to show much better results than it was possible to attain under the conditions with which the Intramural line was necessarily handicapped. It does not appear, as yet, to have been demonstrated that in this class of service electricity is any more economical of fuel than steam when directly used.

THE *Electrical World* publishes an interesting and well-illustrated account of the new electric street-railway recently put in operation in Zurich, Switzerland, which seems to combine many of the best features of both American and European practice. On account of the high price of coal in that country, everything has been planned to secure the highest economy in operating expenses, but this has been done by intelligent and skilful engineering, and not by the makeshift methods with which we in America are only too familiar. The track is 4.6 kilometers (about two miles) in length, and is a constant ascent from the landing on the lake shore to the other end, where a spacious one-story stone building serves for both a power-house and a car-barn. The gage is 1 meter, and the maximum grade 6.3 per cent. for 115 meters. There are two compound-wound generators of the four-pole iron-clad type, each of a capacity of 66 kilowatts, which run at 450 revolutions per minute. Only one of these is run at a time, the other being held in reserve. Each generator is driven by a compound condensing vertical engine, running at 240 revolutions and belted to it as in American plants. There is also an auxiliary engine of 45 indicated horse-power coupled direct to an auxiliary four-pole generator. The most interesting feature of this plant is that the current for operating the cars is derived both from the generator and from a set of storage-batteries coupled in parallel. There are 300 storage-cells of the Tudor type, installed under a ten-years' contract, by which the manufacturers are held entirely responsible for their maintenance and operation. The battery proper comprises only 240 cells, the remaining 60 being used for regulating purposes, and being put in or out of connection as required, by an automatic switch mechanism. The normal capacity of each cell is 245 ampere-hours at 80 amperes discharge, though 160 amperes can be taken momentarily without damage. The aggregate battery is rated at 120 amperes and 550 volts, and is calculated to run nine cars from 1½ to 2 hours, independently of the generators. The auxiliary or regulating cells are charged by the auxiliary generator, usually at the time of lightest load. With the nine cars in ordinary use, the average current output is 90 amperes, although momentary fluctuations vary this from 0 to as high as 200 amperes. The storage-battery serves to take, as it were, the peak of the load, by which a notable economy is effected in the dimensions and first cost of the steam-equipment and generators, these being of but little more than half the capacity that would be required under the ordinary system. The cars, trolleys, and overhead construction are of the familiar American type, and some of the switches and other fixtures are of American manufacture. The line has been in successful operation since March 1, and has done a large and profitable business from the beginning. We shall watch carefully for a statement of the cost of operation of this road, which doubtless will be given to the public in due time.

THE *Electrician* (London) gives an analysis of the capital and revenue accounts of the different electric-lighting companies operating in the British metropolis, from which some interesting results may be deduced. The figures are given on the basis of the 8-candle-power lamp as a unit. The average capital investment per lamp connected is $25, the best individual figure reached being about half that amount; the aggregate gross earnings for 1893 were $1,325,000, and the aggregate kilowatt-hours registered by the house-meters was nearly 10,000,000, an increase over the preceding year of about 25 per cent. The average market price per kilowatt-hour in London last year was 12.76 cents; the average earnings of each lamp connected was about $1.85; and the average cost of coal per kilowatt-hour sold was 2.65 cents, being a reduction of something like 10 per cent. over the previous year. The lowest coal-bill per kilowatt-hour was that of the Kensington company and was 1.48 cents. The *Electrical World* makes some computations based on the returns of the Massachusetts electrical companies to the state commissioners, from which it appears that the average investment of capital per kilowatt capacity of the ten largest stations in

that state is $573, which certainly is a very high figure. The operating expenses in the same stations appear to average about 60 per cent. of the gross income. The average receipts per horse power-hour cannot be exactly determined, but may be reasonably estimated from the returns as given to be about 12 cents per horse-power-hour. This, as will be seen, is considerably more than the London figure.

A RECENT lecture by Professor H. J. Ryan, of Cornell University, gives some points of interest in reference to the construction and equipment of a modern power-station. The amount of floor-space required per horse-power varies from 9.5 square feet for plants of 2000 horse-power and upwards, to 22 square feet for plants of 100 horse-power and under. A fire-proof building of brick and iron may be estimated to cost about $40 per horse-power for 100-horse-power plants, which, for plants of 2000 horse-power and over, falls to $17 per horse-power. The best type of engine for railway power-stations is the compound condensing engine, and the engine capacity should be from 20 to 25 horse-power per car operated. The actual amount required varies from 15 to 18 horse-power per car, sometimes rising to 20 on steep grades. The estimated cost of steam plant is from $45 to $55 per horse-power for high-speed, and $65 to $75 per horse-power for slow-speed engines of the Corliss type. A power-station generator must be absolutely automatic, in practice as well as theory. Machines that do not give an increase of pressure proportionate to load work badly when coupled together. The cost of the electric-generating system, including switchboards, should be from $35 to $40 per horse-power. The switchboard must be mounted on an incombustible base, and a rheostat, voltmeter, and dead-beat ammeter provided for each generator. A trustworthy form of lightning-arrester and a safety circuit-breaker which will act promptly at the point at which it is set, are absolutely essential. Fuses are less reliable than magnetic devices for this work. An essential feature of the switchboard should be an equalizing bar which places the series coils of all the machines in parallel with each other, and thereby prevents the possibility of any generator acting as a motor in case its potential accidentally falls too low, a circumstance liable to result in serious injury to the machine.

PROFESSOR KENNEDY, who has been studying the returns of the electric-lighting stations of Great Britain, states that the cost of coal appears to average not far from four-tenths of the total working expenses of a station. As to the loss in transmission, he mentions that in one low-pressure system, laid out for a loss of 20 per cent. in the feeders, the actual average loss during one year amounted to only 10 per cent., while in the mains and transformers of a high-pressure alternating system, they are usually not less than 25 per cent. of the energy generated; a loss which he thinks might be materially reduced if a less number of transformers of larger capacity were more generally employed.

THE following interesting comparison of the mechanical and electrical methods of transmitting power was given by Mr. L. B. Stillwell at a meeting of railway-men: A steel cable 1½ inches in diameter, traveling at the rate of twelve miles per hour, can transmit nearly 2000 horse-power. But by taking a copper wire, 1 square inch in section and applying to it a potential equal to that which is in use to-day in at least one place in this country,—viz.: 10,000 volts, at 1000 amperes per square inch,—we find we are transmitting in an invisible form over that wire more than 13,000 horse-power, which is enough to rupture instantly six such cables as are ordinarily used in operating a cable railway. As much power can be transmitted through such a copper wire under the conditions named as through six such belts as were seen at the World's Fair, six feet wide and running at the rate of a mile per minute.

THERE has been a good deal of discussion, first and last, in respect to the rea-

son for what is undoubtedly a fact, that the storage-battery has been on the whole commercially successful in Europe, while in the United States it has been, with perhaps rare exceptions, a commercial failure. Mr. W. W. Griscom, in a paper read before the American Institute of Electrical Engineers, gives what we have no doubt is the true explanation of the puzzle. It simply is that in this country storage-batteries are worked with too small a margin of safety. The fault of this state of affairs seems to rest entirely with the manufacturers. As Mr. Griscom pointedly observes: "A storage-battery continually worked to its commercial rating is a commercial failure. A storage-battery worked sufficiently within its capacity is invariably a commercial success." This, being interpreted, means that the manufacturers of storage-batteries, like those of arc-lamps, are accustomed to sell them under a so-called "nominal" rating, which is intentionally fraudulent and misleading. If we buy a steam-engine of 100 horse-power we expect to get one which can be worked continuously, day in and day out, at 100 horse-power, without danger or injury to the machine. If we buy an arc-lamp of 2000 "nominal" candle-power, we may expect to get, according to Professor Anthony, about 500 actual candle-power. The discount on "nominal" storage-battery capacity, according to Mr. Griscom, is not quite so great as this, it being only necessary to add 50 per cent. to the commercial rating as a practical factor of safety. This, it appears, is what is done in Europe, and is all that needs to be done here. Mr. Griscom deserves the thanks of the profession for his simple and obvious solution of a very troublesome problem.

THE advantages of the long-distance telephone as a branch of the military service have been strikingly exemplified during the recent industrial disturbances at Chicago. The president and his cabinet at Washington were in almost continuous session for several days, and, by means of the telephone, were placed in direct and instantaneous communication with the representatives of the government at the front. Not only is there a great saving of time when the telephone is thus used, but the possibility of misunderstanding and mistake are reduced to a minimum. The vigor and promptitude with which this crisis was met by the officers of the government was in no small measure rendered possible by the opportune aid afforded by this great modern invention.

THE Oerliken Machine Works of Switzerland have long been recognized as one of the foremost establishments in the world in the development of modern methods of transmission of power by electricity. One of the finest examples extant of the technical skill and knowledge of its staff of electrical engineers is its own transmission and distribution plant, which is described by Frederick Bathurst in a recent number of the *Electrical World*. The power-house is situated on the little river Glatt, at a distance of about fifteen miles as the line runs, from the Oerliken works. The building is of brick, and is equipped with three horizontal turbines, each of which carries upon its upright shaft a separately excited generator having 32-pole field-magnets, which revolve within stationary armatures of ring form. There are three generators and three transformers, two of each being employed in ordinary work, while the third is held in reserve. The machines run at 180 revolutions per minute, and generate a three-phase alternating current of 85 volts potential, at a frequency of 48. This current is raised to 13,000 volts by transformers immersed in oil, which is cooled by being made to circulate through pipes coiled in a cold-water tank. The line carries four bare copper wires of No. 8 B. & S. gage, upon double-shed porcelain insulators, three of the wires being ordinarily used, and the fourth held in reserve in case of accident. Every fourth pole has a ground-plate and lightning-rod. Two telephone wires are run underneath the power wires, a plan which has proved by experience to be much safer than placing them above as was formerly the practice. The amount of power transmitted is approximately 340 kilowatts and

the line loss does not exceed 2½ per cent. Arriving at the factory, the current is again transformed, being lowered to a potential of 190 volts for general service. There are 40 motors in use in different departments of the works, varying in capacity from 3 to 80 horse-power and running at speeds of from 2000 to 500 revolutions per minute. The smaller motors are supported as a rule upon brackets inserted into the wall, thus economizing valuable floor-space. The wiring and starting arrangements are remarkable for their simplicity, nothing more being required than a three-pole switch fitted with safety-fuses. A 6 horse-power motor will start from rest, either with or without load, and attain full speed within 20 or 30 seconds. In some instances, special starting appliances are found necessary or convenient, especially in the case of the larger motors. Any motor in the establishment will carry a temporary overload of 50 per cent. without injury. One of the most interesting applications of the motors is in the case of the 10-ton shop-cranes, each of which is fitted with three motors; two of 3-horse-power capacity for traversing, and the cross-travel of the trolley-carriage respectively, and the third of 9-horse-power capacity for hoisting. The movements of the first two motors are controlled by a simple double-headed three-pole switch, while the 9-horse-power motor has a simple iron resistance-box with six contacts. Altogether the Oerliken factory furnishes one of the most complete and interesting installations of electrical power-transmission and distribution in the world.

A LARGE and increasing business is being done in the manufacture and installation of small self-contained direct-current plants for isolated lighting. A very compact apparatus of this kind has just been supplied by the General Electric Co. to the new Manhattan Life Insurance building in New York. The generator is of the six-pole ironclad type, giving 25 kilowatts at 300 revolutions, and is coupled direct to the shaft of a vertical 9½″ × 10′ engine, rated at 40 horse-power which is mounted on the same base. Such a combination plant occupies but very little space, and is stated to have given excellent satisfaction.

IT has long been known, or, at all events, strongly suspected, that the quantity of light emitted by an electric arc-lamp, other things being equal, was largely dependent upon the quality of the electrodes used. It is said to be not an uncommon occurrence to come across particular carbons which show a difference of 50 per cent. in the amount of light produced. Professor W. A. Anthony, who has made many hundred photometric measurements, has stated that a 450-watt arc (nominally 2000 candle-power) in a clear glass globe does not ordinarily give more than 500 candle-power in mean spherical measurement. Recent experiments in Germany have given a much better result, 1292 candle-power having been obtained with a lamp of similar capacity. This great difference can apparently only be accounted for by differences in the quality of the carbons, and hence would seem to be a matter that urgently needs further and more careful investigation. It appears to be generally admitted that the carbons made in Germany and Austria are as a rule far superior to those produced in this country.

THE large power-house of the Brooklyn City Railroad Co. is so located that all the coal used has to be transported 1000 feet from the wharf to the boilers. By means of machinery devised and erected by the C. W. Hunt Co., it has been found possible to take coal out of the hold of the vessel and deliver it to the boilers at a cost of three cents per ton.

ARCHITECTURE

Conducted by Barr Ferree.

THE publication of architectural articles in the popular magazines is generally supposed to be a healthy indication of a growing and widening taste in architectural knowledge among the non architectural public. It may be seriously questioned if it is any such thing. Editors are human folk, like the rest of us. They aim to make their periodicals as good as they can. Striving to know everything, they really know very little, and hence are quite unable to bring a specialist's knowledge to their task. There is probably no subject on which they are more readily deluded than on architecture. Architecture in America is so very bad in general, and it is so very easy for wordy persons to write most delightfully and critically upon it, that the very worst things may pass current as the wisest. Architectural criticism, as it is generally practised, comes dangerously near to jugglery with words. Given a few ideas, or semblance of ideas, a smattering knowledge of architecture, which need not be much more than familiarity with shapes and sizes of doors, windows, and other elementary details, and a large vocabulary, and your architectural critic can go blithely forth into the world, seeking reputations which he may make and destroy, looking around for men he may uplift, for others that he may cast down, and at the same time gather in the few dollars that make his attempts profitable to him as they are apparently enjoyable. It is impossible to estimate the evil such a person can do. If he can gain ready entrance to the big magazines, a circumstance that is by no means always due to individual merit either in the writer or in his work, he can in a reasonably short time acquire a vast reputation. People who know nothing of architecture,—and of these there is a vast herd,—look up to him as a huge fountain of light. Architects and practitioners eagerly scan his efforts for praise or condemnation, and their estimate of his ability as a critic is usually based upon his own personal predilection for their work. If he thinks it fine he is a fine critic; if he condemns it the word *condemn* is a very faint way of expressing the opinions they pour forth. That is the great secret of architectural criticism, though, like many great secrets, it is of no special value to the world at large. For the manners and works of architects are as varied as the hues of sunset, and no critic, be his vocabulary as great as the Century Dictionary's itself, can please all. Some must suffer that some be pleased.

SEE the architectural critic sallying forth conquering and to conquer! Armed with no larger weapon than a pen he accomplishes prodigies of valor beside which the combative attempts of the late Don Quixote, of blessed memory, are as babe's play. Mounted upon his favorite hobby-horse he sweeps over the world brushing down all he can and vainly trying to demolish those who persistently prosper, with the utmost bad grace in the world, notwithstanding his efforts to drive them out of business. His armor is nothing more than sets of the latest dictionaries, and with these he rides unscathed through the bitterest battles. From his own standpoint it is a fine sight and fine sport. To those he loves he deals out praise unstinting; to those he hates he administers his severest cuts with the most charming smile and in the very best language at his command. Gayly and wildly he rides, rocking his hobby-horse up and down with a vigor that would make a ten-year-old child die of envy. He bellows loud and long, that all people may bear witness to his prowess and to the puniness, not to say insignificance, of his opponents. These poor people have nothing to say. If they

are sensitive folk they suffer unheard and in secret. If they are case-hardened and dictionary-proof they go calmly on gathering in clients, gaining important pieces of work, and waxing rich, regardless of the bellowings that are intended to efface them from off the earth. The net result, in this last case, is very much like pouring oil upon a fire. The critic will never be downed and he rarely changes his opinion. To do so would indicate a lack of confidence in himself and lower him in the estimation of those people who look upon his ravings with the same interest they are apt to regard "real crawly" cheese after dinner. It is a one-sided contest in which the advantage is very apt to lie with the man who stirs it up. For the man who talks the most often has the advantage over the man who thinks the most, and thinking is a process that the architectural critic can often get along very well without. Of course he does not know this. He regards his effusions as the profoundest essence of thought, and would probably be much surprised if he were told they were not. They can be, it is true, but as it is possible for architects to achieve the highest of architectural successes without any violent thinking exercise, it is quite natural that the critic should follow the same course. School-boys engaged in arguing that much-threshed-out problem, "Is the pen mightier than the sword?" would do well to illustrate their remarks by the performances of the architectural critic.

THE word "Frenchite" is not to be found in any of the dictionaries, and the reason thereof is very clear, since it was first used—and not long ago—in these pages. It is formed from the word "French," the English word applied to the nation and people and things, products, wares, ideas, of and from France. It is therefore one of the most glorious words in the English tongue, recalling and designating as it does one of the very finest countries and people in the world. The word "French" implies nothing that is not honorable; it recalls many momentous events in history; it describes many wonderful and extraordinarily-interesting objects of art; it stands for many pronounced, advanced, and healthy ideas. It is a great word and a good one. It is a very fine word. The suffix "ite" is Greek. The word "Frenchite," therefore, is a somewhat barbarous combination of English and Greek, but no worse than other combinations of a similar kind that are being put forth by most eminent authority every day. The use of the suffix in the present word is the primary one of signifying "a disciple, adherent, or follower of a person, a doctrine, a class, an order, etc." Using the word exclusively to designate the adherents of certain architectural ideas and forms, it has a definite and legitimate meaning. Like the word "French" it is a good word and an honorable one. The true Frenchite should glory in that title as his most valued possession. The characteristic quality of the architectural Frenchite—and we are concerned with no other—is adherence to forms and vehemence and persistency with which certain fundamental elements are accepted, practised, and taught as the fundamentals of architecture in all things, under all circumstances, and in every condition. We are sorry to learn that many Frenchites object to being so designated. Fie upon such men! The word is not a mark of shame, but of glory. It is a word the people can understand, since the "French" portion of it is clear and to the point. It is descriptive as well as expressive. The word "Écolist" may be more elegant, but it is not so picturesquely and directly descriptive. As a new word it has a certain element of strangeness attached to it. But it is a noble word, expressing noble ideas, and referring to noble men. For our own part we should be proud and glad were we able to describe ourselves with this word; but, though more French than most Frenchites in America, we cannot so call ourselves. We trust we can depend on the sympathy of the Frenchites in this our great misfortune.

THE world does move, even in Boston, for the *Architectural Review* has a new editor whose views and sympathies are

very considerably opposed to those that have heretofore dominated that very interesting periodical. The world of architectural students owes a debt of lasting gratitude to Mr. C. Howard Walker, who has lately relinquished the editorship of that publication. Though not its editor from its beginning, Mr. Walker has always been in active sympathy with it, and when it was transformed from a students' organ of the Massachusetts Institute of Technology into a full-fledged, independent architectural journal he naturally became its editor. Its success has been largely due to his industry, sagacity, and judgment, and even those who, like ourselves, differ with him on architectural fundamentals, must regret that we are no longer to have the benefit of his cultured judgment on architectural matters or profit by the ability with which he conducted his periodical. And we do not hesitate to say so, though he has pursued this Department with a venom and vigor that entitles his criticism to rank among the most vituperative of the day. Mr. Robert D. Andrews, who succeeds him, represents a very different school. Mr. Walker is a Beaux-Arts man of the Beaux-Arts, though never himself a student in Paris. Mr. Andrews stands for a broader school of architectural training, and will bring different sympathies to his work. Many interesting changes may be looked for in the *Review* under his management, and its proprietors are to be congratulated on securing so capable and competent a man to conduct it. The *Architectural Review* is the only architectural periodical in America that boasts a practising architect as its editor. This privilege it enjoyed under Mr. Walker and this it will continue to enjoy under Mr. Andrews. There can be little doubt that to this circumstance the *Review* owes the greatest measure of its success. It has been distinctly an architectural journal of architects, for architects, by architects. Architectural journalism in this country has unquestionably suffered from the fact that its journals are not conducted by architects. It may not be necessary to be an architect to be a successful architectural editor, but the history of the *Review* shows what very effective work can be accomplished when this is the case. Mr. Andrews assumes charge of a highly-successful, well-established journal. The preliminary work of placing it upon a firm foundation has already been accomplished. With the new ideas he must necessarily introduce, with the enlarged sympathies he brings to his new task, its scope and success in the future must be greater than in the past. We are glad to welcome him among the architectural editors and felicitate the profession upon the advantages that must accrue to it from his new field of labor.

AN editorial in *Architecture and Building*, some time ago, directed attention to the number of architectural societies in New York, and incidentally pointed out the connection between their growth and the interest in architecture as an art. Some five or six societies were enumerated. The oldest is the New York chapter of the American Institute of Architects, whose value is perhaps not so great to the profession or the public as it should be, but which nevertheless has an importance that cannot be overlooked. The Architectural League, which, under the late long presidency of Mr. Russell Sturgis, acquired an unusual influence, is a much more active organization and, more than the chapter, is the hope of the profession in New York. Its field of work is large and important, and naturally increases from year to year. This, with the Department of Architecture of the Brooklyn Institute of Arts and Sciences, in Brooklyn, brings the list of strictly architectural societies in New York to an end. But allied with them are the artistic societies like the Metropolitan Art Society and the Sculpture Society. Both of these, while occupying somewhat similar ground, are entirely distinct in idea. The Metropolitan Art Society is an organization intended to take up all questions of art affecting the city of New York at large, but more especially in the way of providing opportunities for the carrying out of public works of art. Its first effort has been a competition among painters for the decoration of a

court-room in the new county court-house. This proposal should receive the hearty support of every thoughtful citizen of New York, since the building in question is not only the latest addition to the civic structures of that city, but is also one of the worst. Its exterior being as devoid of artistic interest as is possible in a building, it is a work of positive philanthropy for the Municipal Art Society to seek to give it some artistic interest by decorating one of its rooms. The Sculpture Society is more professional in its aims. It not only takes up the question of sculpture as applied to architecture, but includes conferences among sculptors on professional topics, which are not only of the widest interest to the public but are likely to be of the greatest value to its professional members. The organization of two societies such as these within a single year is ample evidence of the general interest felt in art and its relation to architecture. The governing body in both is composed of painters, sculptors, architects, and laymen, representing all phases of art, and thus having a strength impossible among separated interests. Membership in both societies is open to all interested in the subjects with which they are concerned.

IN no profession does professional feeling amount to so little as in architecture. Medicine stands almost at the other extreme, for there professional feeling is so strong and pronounced as to be sometimes popularly supposed to be a menace to public safety. Doubtless this is an exaggeration, but a fraction of the professional feeling of the doctors could be profitably spared to the architects, to the lasting profit of both. Architecture in modern times has become a personal art in which individuality, so far as it goes, takes the place of schools. The concerted action that produced the marvelous monuments of the middle ages has long since been swept away. Instead of men working in the same line we have men working in individual lines, without the smallest reference to what their brothers are doing. This isolation is felt in more ways than in the development of myriad styles of architecture. It affects unity of work in every direction. There is no "trade" feeling, no unity of thought or of action that is often so powerfully operated in other professions, and even in the trades. The bricklayers, to take an extreme instance, have more unity of feeling than the architects. It is not a very highly-developed feeling, it is true, but it amounts to a great deal from the bricklayer standpoint. The architect can show nothing corresponding to this. If he would raise the standard of his profession by excluding from it all save men of a certain standard of ability, he does not begin by rendering it impossible for those who do not come up to his ideal from obtaining business in a professional way, but carries a bill for licensing architects to his legislature, that the standard of art be fixed by law. If, after years of effort, the architects get a bill through congress permitting a high government official to throw open certain work to them at his discretion, they get muffed if that discretion is used in a way that they think it ought not to be used. This last is not, perhaps, a good instance to quote, since if there ever was a subject on which architects in general were united it was that government architecture should be in the hands of private practitioners, so far as designing and superintendence are concerned. There are many professional questions that should naturally come before architects for professional discussion. The Architectural League is the only body in New York that takes this responsibility upon itself, and even here a good deal of the talk is by those who are not architects. The Society of Beaux-Arts Architects, New York, has, however, a professional standard that it seeks to maintain. Among strictly professional bodies in America it alone has this peculiarity. However one may differ with it in its uses, function, utility and worth, it is impossible to deny that in this, at least, it has struck a note that other branches of the profession would do well to follow.

THE New Orleans *Picayune*, in some remarks on a recent magazine article on high buildings, said that it was impossible to

believe that any one could take an interest in such architecture. The comment contains more truth than the newspaper evidently supposed. It is not true that it is impossible to believe that people could be interested in high-building architecture, but it is true that very many people are not interested in it, and until all who may have occasion to build high buildings, to own them, to transact business in them, to pass before them, to have anything to do with them in any way—until all these are interested in them they will very likely be intensely stupid and dull structures. Very many of them are that and nothing else, and, if it were not that a few men have been wise enough to apply artistic methods to their design and have given the world some interesting buildings, there would be nothing but condemnation for them individually and as a whole. But lack of interest is not limited to high buildings. There is a general indifference to architecture in all its phases even in the most enlightened quarters. This is partly due to the architects, who do not always do the best they can, but more especially to the general public that is quite oblivious of the meaning of architecture. If it goes to architectural exhibitions it finds gayly-colored walls that would put a picture collection to shame for sobriety. If they go to architects they are personally acquainted with, they get that man's own style, which they may not like but which is accepted because they think its designer knows what they want better than they do themselves. There is serious need of interest in high buildings. These costly structures are built to last a long time. They will not speedily be replaced and may be considered permanent. This makes it all the more necessary that they should be designed with the very highest artistic skill. We may, perhaps, not be unduly concerned as to what posterity may think of our work, but for our own sake, to put the question on its proper ground, it is becoming that our largest structures should be possessed of that artistic quality that can only come from general interest in them. It must be reckoned among the anomalies of architecture that men who would not put a hundred dollars into a thing they were not interested in or cared nothing about, will not hesitate to spend a million on a building that may be utterly deficient in architectural merit. They are not properly interested in it. Architects would do themselves a world of good if they would remedy this evil.

AN architect who has succeeded in giving a squat effect to a thirteen-story building has achieved such a success as few can boast of. This is just what the architect of the Postal Telegraph building in New York has accomplished, and he has done it with the simplest means in the world. His design is simple, and, save for an impossible flat archway reaching through three stories and forming the entrance of the building, embraces no especially incongruous feature. The upper stories are sufficiently plain for a commercial building, though the main front has somewhat the effect of not having quite enough windows in it. Light interiors are the first essentials of a modern office-building; but this front seems to have somewhat more wall than is needed. The building starts with a basement in three stories, plainly treated, save for the ugly flat arch just mentioned. Over this comes a mezzanine story, quite unnecessarily thrust in between the base and the superstructure. This last is seven stories high, and here the architect began to get in the fine work that ended in the squattiness of his design. With that strange fascination for the horizontal that amounts almost to a mania with New York architects, he has omitted any expression of the vertical. But in order that his façade be not wholly without some lines of accentuation, he has run a Greek fret across each story, directly under the window-sills, where it cannot even express the floor-lines but is simply a meaningless unnecessary way of slicing up the building. The great feature of this design is contained in the story immediately over the superstructure, which is the eleventh from the ground. This floor is to be occupied by the telegraph company, and that, perhaps, is the reason why it has been made higher than the others. At all

events, the practical results are most distressful, since the elongation of this story, together with the manner in which the building has been cut up into slices by the horizontal lines running across it, produce a compressed effect that may be colloquially described as "squat." The upper portion of the building is exceedingly badly managed. The cornice, which is of copper, is supported by eliptical arches of that material, with an effect that is most unhappy. But the design is not to be condemned offhand. It is not obtrusive, nor does it neglect the commercial requirements of a commercial building. The meaning of the problem has not been fully grasped, nor has the architect been entirely alive as to what he ought to do. Entire success could not have been had in the lines followed.

DURING idle moments architects are prone to consider, for lack of other things to do, the ways and means of advancing themselves professionally and financially. The latter is the more important phase to be considered, and is exactly what any business man would do. There is no reason at all why an architect should not have the privilege of consulting his own advantages. Of course no one will dispute that, but some difference of opinion can rightly enough exist as to ways and means. The licensing of architects is one of these questions that come up when there is nothing at all to think about, and that go down without any one being able to explain why nothing was done. The principle of licensing architects is simply to obtain from the state authority an ability that architects, as a class, are too indifferent to obtain through their own personal exertions. It is an admission,—though perhaps no architect would care to make it public,—that they are not really as important or necessary body of men as they would like people to imagine them to be; they need a legislative act to give dignity to their importance. Doubtless this topic will come up for years to come, and will continue to do so until it has been put into practical operation. If any state will pass a law requiring architects now engaged in the practice of their profession to pass an examination for a license we should think it would do a great deal of good. It might be difficult to get a board of examiners who would know enough to examine; it might be more difficult to set up a standard whereby all architects shall be measured, just as we measure walls in feet, or molasses in quarts. Still the gentlemen who wish this thing done will doubtless be able to provide a way of doing this which will be made public in due time. Meanwhile any one who will devise a scheme whereby the erection of an unpleasant building shall be a misdemeanor, or an offense punishable by law, will be entitled to nothing short of a statue to himself. A community that could legislate against cigarette-smoking might well give evidence of its culture by legislating against unnecessary affronts to public taste. Cigarettes are unquestionably an abomination of the abominations, and the stench they make is quite out of proportion to their size. But however great a nuisance they may be, their odor is not permanent; they may offend us with their presence, but they are not always present. With the ugly building it is very different. The uglier it is the longer it will last, the bigger it is apt to be, the more difficult it is to get away from it. The cigarette is a joy forever compared to some huge, horrid office-building. Yet one is condemned and the other remains with us, to constantly remind us of its horror, to distort our vision, to make us more proficient profanists. Things are not always what they should be, are they?

MINING AND METALLURGY

Conducted by Albert Williams, Jr.

SOMETIMES one poor mine-manager may be better than a dozen good ones. Here is an instance in which the adage that "in a multitude of counselors there is wisdom" does not obtain. Rather should it be said that "too many cooks spoil the broth." If there is any one civil occupation more than another in which unity of decision, authority, and responsibility is essential, it is in the management of a mine or works. It often happens that there are two or more alternative ways in which to reach a given result, and it may be a nice question to decide which to adopt when the arguments for or against either are strong. Now suppose that a board of directors, the superintendent, a consulting engineer, and perhaps some prominent outside shareholders meet to decide upon a line of action,—say the installation of new plant or the kind and extent of underground development. Suppose, further, that each of these men is competent and intelligent. Each will have his own ideas and his own plans to propose, or there may be two or three groups representing so many distinct opinions. The problem is usually complicated by money considerations and policy toward the shareholders, so that there is almost always room for divergent views. Now it might well be that either of two or more plans, entirely distinct, would serve the purpose, and that it would be almost a toss-up as to which should be adopted. Unfortunately the upshot is too often a lame compromise, neither one thing nor another, and operations then go on in a half-hearted sort of way, with inevitable waste of time and money, and with the probability that sooner or later a more radical change will have to be resorted to. Every mining engineer who has acted in an advisory capacity for a company has had to face difficulties of the character here pointed out.

IN order to conduct successfully the affairs of a "company mine," large or small, there must be a systematic organization and a strict division of authority and responsibility, or else everything is muddled and uncertain. The board of directors, so long as they hold office, must have the final say in all matters up to the point where it is advisable to call a special meeting of shareholders to receive authority for making some very serious move. In the current management of affairs they are supposed to be competent and to have the confidence of shareholders, or such a predominating stake in the enterprise that they have a right to dictate. If they go seriously wrong, they can be removed if the outsiders hold enough shares and act in concert. As between the board and the superintendent the relation should be plainly understood. In important matters, involving considerable outlays, the superintendent will submit his projects and obtain approval and authorization to go ahead. In lesser details, however, as for example in ordering work done, hiring men, and contracting for transportation and supplies, he must be the responsible executive officer, if there is to be any system or discipline. When *his* subordinates can go behind his back to the president, or the treasurer, or the board, discipline is at an end. If the board cannot trust him to regulate the general running of the mine or works, let them at once discharge him and get some one in his place in whom they have confidence; but they should never intermeddle with details, or he loses authority and interest. Too frequently the superintendent is looked upon as a mere foreman, and accepts the situation. But a mine in Idaho or Arizona cannot be run from an office in New York or London. Again, as between the superintendent and his staff, if there is any, there must be a

definite understanding and a rigid division of responsibility, so that he in his turn can rely on his foremen, millmen, etc., as to certain minor details, while at the same time supervising all, so that he can give his best effort to the larger questions. When a consulting engineer is called in, his position is usually well defined. He has no authority, except perhaps over those detailed to assist in surveys or experiments, and to incur expenses up to a prescribed limit. He submits his advice and projects, explains them, and his duty is done, without interfering with the superintendent's functions.

THUS far we have been considering the American system of mine management, in its most effective shape. There is a modification of this, common with foreign corporations and followed in a few cases in mines and works operated by American companies. It is to have a resident manager or agent, who attends to the business part of the enterprise, the purchase of material, sale of product, accounts, etc., and, by relieving the mine- or mill-superintendent of these matters, leaves him free to manage the technical side. The superintendent then becomes what English miners know as a mine-captain, or a sort of head foreman. Such an arrangement works well in very large undertakings, if the agent and the mine-captain act in harmony and understand each other. The system is not to be recommended for small or medium enterprises, not merely on account of the additional salary, but also because of the introduction of one more possible element of friction. But, in brief, the whole question of mine management resolves itself into the necessity of strict discipline and systematic division of authority and responsibility throughout.

A NEW pressure-blower, suitable for supplying the blast to smelting-furnaces, has lately been introduced. It is of the same general type as the Root blower, but the two interlocking "impellers" are mounted one over the other instead of side by side. The air passes through the machine horizontally, the intake and the outlet openings being on opposite sides. The manufacturers claim that the design is on true epicycloid curves, and that therefore there is a long contact of convex against concave surfaces, with no loss of power from alternate condensation and expansion of air due to irregular contact, and very little jarring or noise. The secret of success with blowers working on this principle is in securing a close fit between the impellers and between them and the outer casing. As to the relative position of the working parts, there seems to be a mechanical disadvantage in setting them vertically, one over the other, while the horizontal direction of the current is perhaps more convenient.

AS computed by the division of mining statistics of the United States geological survey, the total value of the metals produced in the United States in 1893 was $249,981,866, the items ranking in the following order: pig-iron, silver, gold, copper, lead, zinc, quicksilver, antimony, nickel, tin, and platinum. The total value of the non-metallic mineral products of the United States for the same period, and according to the same authority, was $358,835,629; bituminous coal, anthracite, lime, building stone, petroleum, and natural gas leading. Of course it is hardly fair (as was fully explained in the present writer's reports for 1882-1885) to lump together the values of raw products such as coal with those of products in different stages of manufacture, such as the metals; but as a mere matter of curiosity it may be stated that, including some unspecified items ($1,000,000 estimated), the grand total foots up to $609,817,495—which is far beyond the mineral output of any other country, though somewhat below that of the United States in 1890, 1891, and 1892.

By way of comparison, it is interesting to note that the figures compiled by Mr. R. P. Rothwell (in "The Mineral Industry," Vol. II) come out as follows: In 1893 the United States is credited with $267,707,795 worth of metals produced, $371,376,935 worth of non-metallic minerals, and $6,000,000 unspecified—or a grand total of $645,084,730. Both the Survey and M.

Rothwell rate silver at its coining, not its commercial value.

Roughly speaking, the value of the crude mineral output of the United States, allowing for deductions for transportation and manufacture, is now somewhere in the neighborhood of half a billion dollars annually. When it is considered in how short a time this great mining industry has grown up, outstripping that of all other nations, the showing is indeed remarkable and offers one excuse for "letting the eagle scream."

THE world's production of gold in 1893, as estimated by Mr. R. E. Preston, director of the United States mint, was 7,523,362 fine troy ounces, of the value of $155,521,700, against 7,077,146 ounces, worth $146,297,600, in 1892, being an increase of 446,216 ounces, or $9,254,100. The world's production of silver also, according to the same authority, showed a gain in 1893 over that for 1892. In 1893 the total silver output was 160,794,100 fine troy ounces, of an average commercial value of $125,419,400, against 152,545,500 ounces, having a commercial value of $133,477,300, in 1892. While the quantity of silver increased, the fall in market price made its total commercial value less for 1893 than for 1892; but comparing the respective coining values, according to the United States standard of $1.2929 per ounce, the figures would be: for 1893, $207,895,400; for 1892, $197,230,500—a nominal gain of $10,664,900. The slight though steady gain in gold, Director Preston thinks, will soon bring the total annual gold output to an equality with that of both metals thirty years ago. But Mr. Preston does not take into account the vastly-expanded business, and consequently augmented demand for exchange, during the same period, which, if considered, would place a different appearance upon the available supply of gold for coinage then and now. Besides, it is not the yearly increment, but the total stock, that affects the coin circulation.

SO much attention and apprehension were aroused by the failure of the 18-inch Harveyized nickel-steel armor-plate tested at Indian Head in May, that the report of the successful trial of another plate on June 12, at the same proving-grounds, will be hailed as a relief. The plate in question was from a lot to be used on the turrets of the *Massachusetts*, measuring 12′ in height, 8′ 3″ broad and 17″ thick, curved to 17′ 5″ radius. Two 850-pound Carpenter shells were fired at it, one with 253 pounds and the second with 393 pounds of powder, at 100 yards. Both projectiles were destroyed, neither fully penetrating the plate, which, however, showed a thin crack to one edge after the second shot.

AMONG several letters referring to a paragraph (in the June issue of this Magazine, p. 425) on the cause of the breakage of stamp-stems and the crystalization hypothesis, comes the following suggestion:

The next time anyone lays in a set of new battery-stems let him order a few extra lengths of the same stock and cut off enough for test-pieces. Then keep a record of the length of the run and put aside the broken end, and follow this till there are half a dozen ends for samples. These are then to be taken and planed so as to show a square section normal to the stem axis, and the ends are shaped square and both sides and ends polished. Now etch as usual in dilute nitric acid, and take the usual prints from the unused test-piece and from the broken pieces. Put in the testing-machine and get bending and breaking limits of two or three of the broken ends and compare with the unused test piece. Take another broken end and cut it up, by a saw run slowly, into pieces one-half inch thick, with ends normal to the axis of the stem, and polish one facet. Etch, and print. You will then be able to settle the question as far as those stems and that metal are concerned. If any crystalization is shown, take the stem from which the piece is broken, and cut off two feet of the lower end and plane it so as to give a cut through the center along the longer axis. If there is any conversion from fibrous to crystaline structure, the print after etching will show it fully.

IN this connection the *Carpenter and Builder* remarks:

We do not know that the word "fatigue" properly describes the condition the metal gets into preliminary to breaking, but highly practical grounds exist for the belief that metals become weakened by use even when no incipient

fractures exist. There is a bending or a lengthening and shortening action going on even when the change is too minute for measurement except with exceedingly exact instruments. This movement of the metal causes molecular changes, which reduce the adhesion of the particles, and thereby make the metal weaker. Nearly every observing mechanic has noticed breakages where it appeared that steel or iron originally good had become so brittle and roughly crystaline that it was unfit to sustain an ordinary load. A case occurred some years ago on a well-known railway, which appears to be a good practical illustration of the correctness of theories concerning the fatigue of metals. The company got six new switching-engines that were put into the same hard service in a yard where there was a great deal of running over switches and frogs that subjected the running-gear to severe shocks. The engines were all of the same pattern, strongly built, with unusually heavy axles, the designer believing in a good margin of strength. After these engines had been in the service for several years, one of them broke an axle. An inspection of the fracture showed that what was originally fine fibrous iron had become coarsely crystaline, the molecular change, no doubt, having been induced by the constant jars. Within six months all the six engines failed with broken axles, and the fracture in each instance showed the same condition of the iron.

Some of this "fatigued" metal was reworked and made up into locomotive parts subject to severe strains, and gave good service. This agrees with and bears out the statement made by Mr. W. L. Austin that annealing prolongs the life of battery-stems, and also the experience of millmen who have had broken stems welded and annealed, after which they were serviceable.

THAT wrought-iron and steel do crystalize under long-continued jarring seems to be the almost unanimous opinion of the profession and of the men who make and use machinery subject to such stresses. There is a possible alternative explanation of the failure of metal under these conditions, as explained in the June issue of this Magazine; but unquestionably the weight of opinion, not only of the older authorities but also of the practical men, favors the crystalization hypothesis. The dicta of Wöhler, Weyrauch, Fairbairn, and others, the experiments of Mr. William Metcalf, and much similar evidence, have been cited in its support. The writer has also been shown many letters from machine-shop managers and mill-superintendents, all of whom believe that the best fibrous cold-rolled iron or low-carbon steel, as used in battery stems, and worked up with special care, crystalize under the continuous heavy jarring in service.

ONE metallurgist of experience writes on this head:

> You may object to my statement that wrought iron will "crystalize;" but fifteen years ago people did not dispute that statement as they now do. "Crystalization" may not take place; but *something* happens to the iron—molecular disintegration or weakening of some sort.

This is rather non-committal, and is certainly safe. No one denies the fact that metals deteriorate more or less rapidly under trying conditions, as in the hard usage of the stamp-battery and of parts of other machines most subject to vibration and jar. The question is as to the explanation; and as to that, if a vote of experts were taken on the crystallization issue, there is no denying that the ayes would carry by a large majority.

A MACHINE for testing the behavior of iron and steel under repeated shocks was devised and described by Mr. William Kent in 1879.* The design was to test metals by repeated blows, numbering millions if necessary. The test-piece is a round rod of convenient length and diameter, and the blows are applied in the direction of the length, as in tension tests. A small nut serving as an anvil is screwed or otherwise fastened on the bottom of the rod, and an annular weight is caused to drop upon the anvil by rotating double cams. The weight of the drop being known and the height of fall being uniformly adjusted, each blow gives an impact of the same number of foot-pounds. A revolution-counter

*Transactions American Institute of Mining Engineers. Vol. VIII, p. 76.

attached to the driving-shaft indicates the number of blows given. Mr. Kent's testing apparatus gives what might be called blows of tension; but it could evidently be modified so as to give blows of compression. In that case it would really be a miniature stamp-battery in which the number of drops could be increased, to save time, from the 60 a minute proposed by Mr. Kent, or the 90 to 110 per minute of fast-running batteries, to a speed that would only be limited by the tendency of the rapidly rotating cams to toss the tappets or not clear them. It might be objected that the difference in weight and size between such an apparatus and a regular battery might give different effects. The stamp-battery may itself, of course, be considered a sort of testing-machine on a large scale.

AN exhibition of mining and metallurgy will be opened at Santiago, Chile, in the second week of September. The schedule of sections into which the exhibits will be divided shows that pains has been taken to make this a very systematic exhibition, and it is to be hoped that American manufacturers of mining machinery, motive plant, electrical appliances used in mining and metallurgy, the chemical industries, etc., will be fairly represented. The Chilean government will convey free of charge to the exhibition articles suitable for exhibit, and will also pay the passage money by sea and land of the workmen and operatives whom exhibitors may send for the purpose of setting up and running the machinery and apparatus. Exhibits will be in private bond; that is, if reshipped within twelve months the promissory notes for customs duties will be cancelled. Awards will be in three classes, with medals and diplomas. Applications for space by intending American exhibitors should be made to the Chilean legation at Washington.

CUBA presents an excellent market for American machinery and manufactures, which, though immediately at our doors, has by no means been adequately exploited. The recent installations of coal-handling plant by the Link-Belt Engineering Co., of New York, show that one portion of the field at least is being occupied. One of these plants lately completed near Havana, for unloading and storing bituminous coal from schooners, is the largest coal-handling equipment in the island. Another similar plant is being erected by the same company for the electric-light station at Havana. There should be room for much more American machinery and appliances in connection with the great iron-ore, sugar, and other industries of Cuba.

COMMENTING on the recent German experiments in smelting iron-ore by electricity, the *Engineering and Mining Journal* says that an apparent technical success is shown, but that much is left to be desired from an economic point of view. The inventor, who would naturally make out the best case possible, puts the cost of making pig-iron at $9.65 a ton, with ore at $2.40 a ton, with a possible reduction of $1 or $1.50 per ton of iron with a large plant, when not less than 1000 horse-power is available. Now, as the *Journal* says, a cost of $9.50 or $8.50 for pig-iron in the present state of the market will not leave a margin of profit and induce ironmasters to abandon blast-furnaces and put in a new and costly plant. It is evident that a considerable reduction in cost will have to be made to render the electric smelting of iron a commercial success. These experiments, however, are highly interesting, and possibly point to an entire revolution in iron-making at some time, perhaps not so very distant, when conditions have changed and expenses are lowered. Such a state of things is by no means inconceivable, though not yet in sight.

DURING the twenty-one years ending with 1892 New South Wales produced 121,912 tons of tin, including ingots and tin in ore. The report of the colonial department of mines states that the supply of tin is ample for all home requirements, the deeper lodes having yet been scarcely touched. The manufacture of tin-plates has not yet become one of the industries of the colony.

A COMPANY has been formed in Chicago to utilize some discoveries said to have been made for purifying, hardening, and tempering copper. If the process accomplishes only a part of what is claimed for it, a new industry would be opened. The copper thus treated is said to be much harder and stronger than ordinary commercial copper, to make large solid castings without blow-holes; to make bells; and it is reported that tests at the Washington navy-yard showed not only increased strength but that the metal was pure, unalloyed copper. All this reminds us of the rather mythical process asserted to have been possessed by the prehistoric miners of the Lake Superior copper-region, by which they are supposed to have hardened the celts, hatchets, and other tools made of native copper. This supposititious lost art (which is now pretty generally discredited) has been the object of search by inventors and metallurgists for a long time. It is possible that the new method succeeds in doing what the aborigines are thought to have done but probably never did. The field has always been an inviting one.

IT is reported that immense beds of nitrate of soda ("Chile saltpeter") have been discovered in Colombia. They are claimed to cover thirty square miles, with a thickness of from 1 to 10 feet, and at a depth of from 8 to 20 feet below the surface. An enthusiastic statement, which must be taken with some deductions, places the quantity "in sight" at over seven billion tons of "caliche," assaying 11½ per cent. nitrate. As these discoveries are said to be on and near navigable streams running into the Caribbean sea, they are much nearer the markets of the world than the Chilean nitrate-beds, so that if the find proves to be at all like what is asserted, it will be of very great importance.

WHILE many forms of portable electric safety-lamps maintained by small secondary batteries have been devised and experimented with, some of which have given remarkably good results, at present the most progress in a practical way for lighting fiery coal-mines by electricity seems to be in the system now quite extensively introduced in European collieries, of using incandescent lamps with double glasses, in circuit with dynamos at the surface; these lamps being used to illuminate main workings and roadways, while some form of oil safety-lamp is retained as a portable illuminant.

AT model German collieries much attention is given to the comfort and health of the men,—lavatories, drying-rooms, and other conveniences being provided. The miners change their clothes before going underground and on coming out, each man having a numbered hook with three branches on which to hang his clothes, and these hooks can be drawn up to 12 or 15 feet above the floor. In this way the clothes are dried and aired rapidly by steam coils, are kept safe, and the ventilation, heating, and supervision of the change rooms regulated and cleanliness promoted.

MANGANESE ore was produced by five states in 1893 — Arkansas, California, Georgia, Tennessee, and Virginia—while in the preceding year only Arkansas, Georgia, and Virginia produced manganese ore. The output of these three states declined, while California and Tennessee together yielded only 882 tons in 1893.

TAMARACK copper-mine, Michigan, continues to hold the record for deep mining. No. 3 shaft had, on May 18, been sunk to 4020 feet vertically, and No. 4 to 3915 feet. By the time this note is printed both shafts will have made considerable progress. These two shafts are now the deepest of any in the world.

SOMEONE having called Cochiti, the new gold and silver district of New Mexico, a "poor man's camp," the *Prospector* grimly remarks that "this may be said with emphasis of all silver-mining camps just at present."

THE total value of the mineral production of Canada in 1893 was $19,250,000, a quarter of a million less than that for 1892.

CIVIL ENGINEERING

Conducted by John C. Trautwine, Jr.

STRUCTURES which are meant to maintain wide differences in pressure between great masses must be wisely and skillfully designed and constructed, and afterward carefully inspected. Even then disasters may occur—disasters proportional to the intensity of the pressure, to the masses involved, and to the suddenness of the outburst. This is true, not only of engineering but of social structures; not only of reservoir embankments and steam-boilers, but of those economic systems which permit and encourage the development of sharp contrasts between wealth and poverty. A structure inherited from a past order of things and ill-adapted to the changed conditions of the present is morally certain to go out, and the valley must take the consequences. It may be very reprehensible for the particles under pressure to move as they do, but it is well for those in charge of the structure to observe the facts, as indicated by history, and to design accordingly.

It is hardly to be expected that a jet, escaping from the lower portion of a high and leaky dam, should pursue that course which to a dispassionate observer might appear the best adapted to accomplish its own purpose—if purpose it have; and so it is perhaps not to be wondered at that presidents of republics, as well as emperors, occasionally fall victims to the bullet or knife of the assassin. In Sadi Carnot the community loses, not only the president of a republic, but an engineer of education and experience, and the descendent of one who, as a mathematician, made the name of Carnot immortal. Those Americans who, in 1889, received the courtesies of the French engineers in Paris, will mourn his loss as one personal to them.

THAT the annual conventions of the American Society of Civil Engineers are enjoyable occasions, goes without saying. The place of meeting is usually so well chosen that the mere outing which the convention affords is in itself a treat; while the pleasure of again grasping by the hand the friends whom one has so pleasantly met a year (or perhaps a score of years) before is a far greater one. But the convention recently held at Niagara Falls will, we think, pass into history, not only as one of the most largely attended, but also as one of the most enjoyable of these occasions. The magnitude of the attendance was chiefly due, no doubt, as we have already hinted, to the wise selection of a site not too far from the center of mass of the membership; while the beauty of the spot and the unusual interest of the engineering works to be seen there readily account for the fact that, in spite of the prevailing hot weather, those who took part expressed themselves so generally as being delighted with their experience. The special day train of Pullman cars, placed at the disposal of the members by the courtesy of the Lehigh Valley Railroad Co., was well filled by members and guests from New York and Philadelphia and from points beyond, and gave them perfect facilities of enjoying not only the beauties of the Lehigh and Wyoming valleys, but also those of the new short line running from Van Etten Junction to Geneva along the high ground just back of the east shore of Seneca Lake.

Not a little of the enjoyment of those who faithfully attended the meetings of the convention was due to the eminently sensible suggestion of President Craighill, at the opening meeting, that the papers should be read in abstract only. It seems unpardonable to inflict upon an audience the reading at length of a technical paper, copies of which are already in the hands of all interested hearers, and it is devoutly to be wished that this imitation of the practice of the American Society of Me-

chanical Engineers may become the rule rather than the exception, with "the Civils."

PRESIDENT CRAIGHILL, in his annual address, enlarged upon the subject of coast-defense, holding that guns and land batteries have always the advantage over ships, however heavily armored, so that, as the soldier has dropped his armor and has come to rely solely upon the efficiency of his armament, the near future may see our battle-ships stripped of their heavy plating, and adapted rather for offense and for flight than for resistance by means of their walls, realizing the remark of Admiral Farragut that broad-sides are better than iron-sides. Colonel Craighill expressed the hope that the Nicaragua canal might be speedily completed, and that under the control of the United States, in order that our vessels may have ready and undisputed passage from the Atlantic to the Pacific and vice versa. He emphasized also the importance of establishing a system of land-locked communication between New York bay and the Gulf of Mexico by means of the series of bays and inlets which line our Atlantic coast in an almost unbroken succession between the waters named, a scheme which, as already remarked in these pages, formed one of the favorite projects of the late Captain Spencer C. McCorkle.

The presidential address was followed by the reading of a very elaborate paper prepared by Dr. Coleman Sellers, and describing the works of the Cataract Construction Co.

AFTER visiting these works and those of the Niagara Falls Paper Co., where the turbines designed by Mr. E. Geyelin, constructed by R. D. Wood & Co., of Philadelphia, and described in these columns in May last, were seen in operation, the party proceeded to the works on the cliffs of the Niagara river below the falls, where are located a number of mills taking their power from the old hydraulic canal of the Niagara Falls Hydraulic Power and Manufacturing Co., completed in 1861. This canal, leaving the river above the falls, not far from the point where the new development takes its water, passes behind the town of Niagara Falls and delivers its water to the mills referred to. Here it passes to turbines placed at the bottoms of pits excavated in the cliff near its brink, acting under a head of about 100 feet and discharging their waste water into the river below, in a large number of picturesque little falls of something like 100 feet in height. One of these discharges has, however, been harnessed and put back to work again, being led through an inclined iron flume, 8 feet in diameter, to the wheels of the pulp-mill of the Cliff Paper Co., which was built within the last two years upon the lower river bank near the water's edge. This plant was described in a paper read before the convention by Mr. Wallace C. Johnson, the engineer of the canal company.

TO the well-regulated British mind no idea is more distasteful than that of innovation, however peaceably accomplished, except that of innovation accompanied by an uprising of "the masses." If those opposed to a suggested departure from established methods have any fear of its prevailing in spite of the national conservatism, they have but to show that in other countries such departure has happened to be coincident with revolution, and its doom is practically sealed.

And so we find the chancellor of the exchequer gravely pointing out that this has been the case with the metric system, and that notably in Germany the adoption of that system took place in troublous times and as the result of a great war and of those developments which led up to the unification of Germany.

With our British brethren, naturally predisposed against the innovation, this sort of thing may well be expected to pass for argument; but Mr. J. Emerson Cowson, member of the Institution of Civil Engineers and chairman of the executive committee of the new Decimal Association, now contributes to the *Chamber of Commerce Journal* a paper on metric weights and measures, in which he undertakes to refute the statement of the chancellor of the exchequer. From this paper it appears further

that the Associated Chambers of Commerce and the new Decimal Association have now resolved to press the adoption of the metric weights and measures, and that a petition praying for the appointment of a select committee to consider the subject has been presented in parliament with the signatures of a large number of influential members.

WHILE little or nothing is now heard of the late Captain Eads's projected ship-railway across the isthmus of Tehuantepec, and while, on the other hand, various schemes for the resuscitation of the ill-fated Panama canal are ventilated from time to time, the matter of the Nicaragua canal, to which we have already referred as being mentioned in Colonel Craighill's annual address before the American Society of Civil Engineers, is receiving renewed attention. In April last the senate committee on foreign relations reported favorably upon a bill guaranteeing $70,000,000 bonds of the Maritime Company and leaving 70 per cent. of the entire capital stock of the company in the ownership of the United States and 16½ per cent. in the treasury of the company; and a special committee has been formulating a new bill providing for governmental control of the canal. The fact that the St. Mary's Falls canal, connecting the waters of Lake Superior with those of the lower lakes, has for three years out of the last four passed a tonnage greater than that of the Suez canal, is urged as evidence of what may be expected from the construction of the Nicaragua canal.

THE report of Mr. Desmond FitzGerald, resident engineer, in the annual report of the water-supply department of the city of Boston, for 1893, states that, owing to insufficient storage-capacity, the color of the water supplied to the city has been increasing somewhat during the last two years, and much space is accordingly devoted to the investigations now being made at the biological laboratory at Chestnut Hill upon the colors of the various waters supplied. The color is found to be derived chiefly from swamps on the Sudbury-river water-shed, a source which it is proposed to attack by draining some of the swamps. Weekly examinations of the color are made by means of the platinum standard recently suggested by Dr. Allen Hazen, in which the color of a water is designated by the amount of platinum, which, in acid solution, with so much cobalt as will match the hue, produces an equal color in distilled water. The nesslerized ammonia and natural water standards formerly used at the filter-station have been found to be of very little value for accurate color, readings, and Dr. Hazen's platinum standard has accordingly been adopted for use in the filtration experiments.

With the true Bostonian tendency to originality, the department has also departed from the old method of giving the number of organisms per cubic centimeter of a water, and has substituted the proportion of a standard area seen to be covered by such organisms and by amorphous matter. The new method has this advantage overthe old, that it takes into account the dimensions of the organisms, and it is claimed that, if proper judgment isused in estimating the thinness and thickness of organisms, the new unit will have substantially the same value as a unit of volume.

THE last report of the Boston city engineer, Mr. William Jackson, devotes much space to the matter of the corrosion of water-pipes by electrolysis from the return currents of electric-railway lines, and embodies a report by Messrs. Stone and Webster, electrical engineers, who were detailed to investigate and study the problem. The only cases of electrolysis of water-pipes distinctly traceable to the action of such currents were those of lead service-pipes in the vicinity of the power-station of the West End Street Railway Co. on Albany street. Here a measurement of the differences in potential between pipes near the station and others at more distant points, differences plotted in two diagrams furnished with the report, show incontestably the presence of electrical action such as may very fairly be suspected of being the source of the trouble, but the engineers hesitate as yet to pronounce posi-

tively that the injury proceeds entirely or chiefly from this source, or that the corrosion noticed is a serious factor in shortening the life of the piping system as a whole or of any part of it in particular. They strongly incline, however, to the opinion that serious corrosion may be now proceeding.

The department complains of constant trouble from the submerged water-pipes in Boston harbor. These are liable to freeze in exposed places at low tide and to be disturbed by currents in the channels, and the department therefore urges the construction of storage-reservoirs upon the islands. It is claimed that the new 20,000,000-gallon high-service pumping-engine built by N. F. Palmer, Jr., & Co. (New York), at the Chestnut Hill station, is "the best pumping-engine in the United States." Like other cities, Boston has felt the necessity of looking about for an increased source of water-supply, and the State Board has been investigating the Nashua river above Clinton, whence it is believed that a sufficient quantity of good water could be procured to supply all the communities within a radius of ten miles of the state house for many years to come.

THE report of the street department shows that with characteristic conscientiousness the city of Boston has been exercising itself over what it terms its smoke nuisance, although one would suppose that by virtue of its relative proximity to the anthracite-coal regions, it should enjoy considerable immunity from this trouble as compared with western cities. By authority of an act of the legislature passed in May, 1893, and requiring that at least 75 per cent. of all smoke produced shall be consumed or suppressed, the mayor directed Mr. Henry H. Carter, superintendent of streets, to see to the enforcement of these provisions. An investigation was accordingly instituted by that official, who finds that most of the nuisances developed result from insufficient air-space and chimney capacity and from forcing of the draft. In this latter respect, the electricians again appear as the chief offenders, for many of the most serious smoke nuisances of the city are caused by the fires under boilers furnishing power for electric-light dynamos, the draft being forced at the hour when the lights are turned on. The superintendent believes that "no matter what style of combustion chamber is used, or what device for smoke-prevention is added thereto, if an irresponsible and careless fireman is employed, no good results can follow."

An interesting comparison of Boston with other cities in the matter of street paving shows that Boston makes up for some of her progressiveness in other matters by being rather conspicuously behind her sister cities in this respect. In February of this year she had less than six miles of sheet asphalt, as against nearly 212 of Telford and MacAdam and 136 of gravel, while even in non-progressive Philadelphia there were eighty miles of sheet asphalt, or over 9 per cent. of the whole system, and in Buffalo 38 per cent., or 150 miles, were of this material, making an asphalt mileage said to be equal to that of all the cities of Europe, where this system of paving has been in use for forty years. The inferiority of the Boston pavements is found to entail a very heavy expense for street cleaning.

As a measure of relief to the unemployed, a number of sewers, aggregating about 14,000 feet, which would not ordinarily have been built during the winter, were constructed, and were in part paid for out of the fund raised for the benefit of such persons.

The report states that the main drainage-works, constructed some ten years ago, have ever since been working in an unfinished condition, and consequently at great disadvantage. Attention has been repeatedly called to this condition of affairs, but the necessary appropriation for the completion of the works has not been forthcoming. The bills for repairs are correspondingly heavy. Work on the gates and frames in the discharge sewer brought to light an interesting example of the action of sewer-gas upon mortar, as compared with that of the sewage itself. The mortar between the bricks above the surface of the sewage was eaten out to a depth

of an inch, while that below the surface was intact.

To judge from the remarks here made upon the use of dynamite, the reader might suppose that the employment of that material for blasting was a matter of recent introduction; for considerable trouble has arisen from accidental explosions, arising chiefly from efforts to warm the material for use in cold weather. A common practice is to heat the cartridges in the pine boxes in which they come packed; but a box, if used for some length of time, becomes in itself a source of danger, the wood becoming saturated with the liquid nitroglycerine and sensitive to concussion.

The report contains a complete compilation of all laws and ordinances under which sewers have been built in the city of Boston, beginning with an act passed at the session held at Boston in 1709 for "regulating of drains and common shores" (sewers). This ancient act was designed to regulate the same difficulty in the way of the breaking-up of streets for the laying of such drains, etc., as is experienced in most cities at the present day.

MR. ELMER L. CORTHELL, late chairman of the general committee on the International Engineering Congress, to whose suggestion for the formation of an International Institute of Engineers we referred in THE ENGINEERING MAGAZINE for June, has now formulated a proposition for this purpose. The principal objects of the proposed Institute, which is to be called the International Institute of Engineers and Architects, are the provision of a suitable channel for the international exchange of information respecting engineering and other works and discoveries, and the conduct of tests of materials and the publication of the results of such tests through the channels of the Institute. It is proposed to admit to fellowship in the Institute "any person engaged in the profession of engineering or architecture, of mature age and of good character." The governing bodies are to be national boards of direction, with an international board of direction and an international executive committee. The dues are fixed at $10 (or equivalent) per annum. The papers and discussions, after final approval by the executive committee of the international board, are to be edited monthly and supplied to each fellow. The Institute is to be divided into eight divisions, corresponding to the departments of civil, mining and metallurgical, mechanical, electrical, marine and military engineering, engineering education, and architecture. The proceedings are to be printed in English, French, German, and Spanish, each fellow to be supplied with the proceedings in the language specified in his application for fellowship, or subsequently. Both metric and English measures are to be given in each paper and in the discussion. It is proposed that the general office and domicile of the International Board and of the Institute shall be in the United States, but the particular city is not specified. The first congress of the Institute is to be held in Paris in 1900, and quinquennial congresses are to be held thereafter, the place of each to be determined by the one preceding it.

IN THE ENGINEERING MAGAZINE for March reference was made to the elaborate series of experiments upon the flow of water over weirs, conducted by the great French hydraulician, M. H. Bazin. Three series of these experiments had then been published, concerning themselves respectively with vertical weirs over which the water flows in a perfectly detached sheet, with inclined weirs and the determination of the pressures and velocities within the falling sheet, and with cases where the sheet hugs the face of the weir, the air being prevented from entering behind it. In the fourth series, the account of which in separate form is just at hand, the distinguished author pursues his investigation of cases of the kind last named, with special reference to the effect exerted upon the fall and upon the velocities and pressures under and within the falling sheet, by changes in the level of the down-stream surface. This series completes the study of weirs with sharp crests. In the fifth series the investigation will be extended to cases of flow over wide-crested

weirs. During the progress of these experiments upon weirs, the same indefatigable investigator has been engaged upon similar researches into the behavior of jets issuing from vertical and horizontal orifices of different forms. In these, as in the weir experiments, M. Bazin has availed himself of that extremely delicate instrument, the Pitot tube, as elaborated by Darcy, and has, by its means, explored the interior of the issuing vein and determined the pressures and velocities at different points of its interior.

As a result of these studies, M. Bazin finds that, in streams issuing from vertical orifices, the minimum velocity occurs a little above the center of the orifice, and that the coefficient of flow through a rectangular orifice flush with the bottom of the reservoir, extending across its entire width and prolonged down-stream at its ends by boards which prevent the divergence of the outflowing stream, is 0.626, or at least 0.02 greater than for circular or square orifices of the same height. Poncelet and Lesbros had pointed out that the velocity through the contracted vein of a jet issuing through a square vertical orifice is somewhat greater than the theoretical velocity. M. Bazin, while recognizing this, inclines to attribute it to the fact, just noticed, that in such orifices the minimum velocity is found, not at the center but somewhat above it, a peculiarity due, no doubt, to the action of gravity in increasing the velocity of the filaments below the center. Investigating the profile of a jet issuing from a vertical orifice M. Bazin finds that the curve formed by its axis falls somewhat within or below that described by a heavy body issuing horizontally with the same velocity, and accounts for this by the action of the resistance of the air upon the entire surface of the liquid vein.

A committee of the Institute of France, reporting upon the memoir in which M. Bazin discusses these results, unanimously asked its insertion in the *Recueil des Savants étrangers*, a collection embracing the researches of Poncelet and Lebros, of Poiseuille and of Darcy, and the earlier contributions of M. Bazin himself. The recommendations of the report were adopted.

MR. CLEMENS HERSCHEL, finding that the development of hydraulic works and the corresponding improvement of the country are impeded in default of a provision extending to enterprises of hydraulic engineering the same right of eminent domain enjoyed by enterprises connected with matters of transportation, seeks to have such a provision introduced into the constitution of the state of New York. He has accordingly issued to delegates to the constitutional convention a circular setting forth the merits of the case, and pointing to the fact that the constitutions of eight of our states already contain such provisions, while in other states laws have been passed granting such powers. Land, he claims, is now held in parcels too small to permit of its taking by private purchase as was done in the days when the great manufacturing towns of New England and of New York state were started; and the necessity for such a movement as is here contemplated has been rendered far more urgent by the introduction of electric power-transmission, by which water-powers may readily be rendered available at great distances from their sites.

THE Hennepin canal, which is to connect the Illinois river near its great bend with the Mississippi near Rock Island, crosses the intervening divide by an elevation of over 200 feet, necessitating a formidable succession of locks; and, as good stone for the masonry was not obtainable in the neighborhood, it was decided to use concrete exclusively in the work now in hand. This work was described in detail in a paper read by Mr. J. W. Woerman in a paper recently read before the Engineers' Club of St. Louis, and in which it was claimed that this will form one of the most extensive pieces of concrete construction yet undertaken in the United States.

MECHANICAL ENGINEERING

Conducted by Henry Harrison Suplee.

ONE of the most interesting features of the Engineering Congress last year at Chicago was the closing session, when the representatives of the various branches of the profession from all other parts of the world gave greeting and farewell to their brethren in the United States. On that occasion an incident occurred which may prove almost the counterpart of the historic "*billig und schlecht*" criticism which Professor Reuleaux made at the Philadelphia Centennial, and which, while due to a misunderstanding of the words of the same honored professor, may result in consequences of much value in more directions than was at all intended at the time As is well known, Professor Reuleaux spoke with evident appreciation of the wide extent to which the use of measuring instruments of high precision existed in American shops, and, through the misinterpretation in Germany of an imperfect report of his remarks in an American journal, he soon found that he had stirred up a "tempest in a tea-pot" among his countrymen and that he was charged with making the broad assertion that America was far ahead of Germany in the entire matter of mechanical measuring appliances. Professor Reuleaux did his best to explain the matter, but without success, and he has now replied to his detractors in a manner which may lead them to regret their action. In a pamphlet, an advance copy of which is before us, he goes most thoroughly into the entire subject of the state of the science and practice of exact measurements in this country. He takes up the gage of battle and proceeds to show that Germany really has much to learn upon this most important subject.

"I have been forced," says he, "by the attacks here to lay before my engineering countrymen the clear state of the measuring question in Germany. I would have preferred and had the intention to give descriptions of the American progress gradually, as that would have been much the better plan. Now my antagonists have forced me to show how very far we are behind. There is no doubt that we will come to the front again when all the advantages of excellent measuring are understood. It was very hard for me to be forced to say what I have said but it was not to be avoided after the excitement which my antagonists had provoked."

This is plain language, but Professor Reuleaux knows whereof he speaks and, indeed, we have nowhere in English such a complete and compact record as he gives of the present status of the subject. His fully-illustrated pamphlet is almost important enough to warrant translation for reference here. The spirit of national pride is nowhere stronger, however, than in Germany, and we may feel very sure that the clear presentation which this pamphlet has given to German engineers and machine-tool builders of American methods and devices, together with the quiet but forcible prodding which is involved in the inevitable comparisons and which compel one's attention, will result in an immediate and rapid advance in this matter in Germany which may make Americans look to their laurels.

WHILE not altogether within the scope of a department of Mechanical Engineering, yet it may be of interest to those of our readers who have the privilege of a personal acquaintance with Professor Reuleaux to know that he has expressed his appreciation of America in another manner, namely, by translating into German Longfellow's poem "Hiawatha"! This has just appeared in a dainty little volume, the translation being most poetically done in the exact versification of the original, and the accompanying notes by the translator evince a familiarity with the spirit

and beauty of the original poem which shows that the Professor's engineering studies have not taken either poetry or romance out of his nature.

WE have frequently referred in this Department to the advantages and growing appreciation of graphical methods in calculations for mechanical work. These are, of course, much used in such work as the construction of strain diagrams, etc., but it is the use of graphical calculating-machines, if they may be so called, that we now have in mind. The slide-rule is as old in principle as the days of Gunter, but its growing use in the drawing-room and field is much more recent. Many years ago the late Mr. John W. Nystrom, a man whose ability never met with proper recognition, invented a calculating-machine based upon the principle of the logarithmic spiral, but it was too expensive to be available for general use, although he himself demonstrated its value and utility. The more recent forms of slide-rule give results which in most cases are quite accurate enough for all practical purposes, and, even where the result is desired to a greater degree of precision, the slide-rule gives an independent check which is most reassuring. In many cases much labor may be saved in preparing tabular work by calculating only a portion of the results and plotting these as ordinates through which a curve, carefully drawn by means of a flexible spline, will enable the intermediate values to be determined with a degree of precision limited only by the practicable scale of the diagram and the skill of the operator.

A novel and most ingenious form of slide-rule has been devised by Mr. J. W. Sexton, of Philadelphia, and those who know the mathematical attainments of this gentleman and his familiarity with what has already been done in this field will be prepared to receive with much interest the announcement of completion of this valuable aid to the engineer.

REFERRING to the interesting communication of a correspondent in the last issue of this Magazine, commenting upon some points made in this Department about aërial navigation, there is no doubt that close imitations of nature are not always the best methods for mechanical devices, and this is probably as true of navigation in the air as it has been in the water. We do not propel our vessels exactly as if they were fishes, and we shall probably not fly in machines closely resembling birds. At the same time, the low efficiency of screws as applied to lifting and propulsion of airships has been demonstrated to an extent which will probably compel the use of some form of supporting aëroplane in connection with them if they are to be used with any degree of success. As noted by the writer in reviewing some recent works on this subject in the last issue of this Magazine, neither screws or wings give results which warrant their use alone, and while we should not attempt to imitate the bird too closely as an actual model of construction, yet it must not be forgotten that the bird *can* fly, and that thus far man has not succeeded in performing that desirable feat to his entire satisfaction, and that we should not despise any points which may be obtained from our feathered companions who may not be exactly laughing in their sleeves at our efforts, but who doubtless would be doing so had they those modern capacious articles in which to conceal their amusement.

LABOR disturbances of any sort are usually followed by numerous panaceas which are offered to prevent such difficulties from occurring in the future, but until all labor is performed by machinery the element of friction will probably exist in the personal sense as well as in the mechanical. There is one phase of modern mechanical development, however, which may have an economic importance not altogether at present appreciated in this very matter of employer and employé. The modern methods of transmission and subdivision of power may result in the decay of the factory system and restore, in great measure, the status of the individual workman, while at the same time retaining for that workman the same efficiency as is now possessed by him in the great workshop. The necessity of concentration

of power in order to obtain highest efficiency has been the real reason why the individual workman, with his own shop and personal control of his own product, could no longer compete with the great organizations which can only be possible with organized capital. Should each man become his own employer again, however, with ample power at his command, as he now can command light, heat, or electricity, he may strike or lock himself out, or do as may please him, but if he has a fair measure of common sense and ability he will do neither but work for his own profit and become the measure of his own value to himself.

MUCH has been written about the regulation of steam-engines and many are the ingenious devices which have been made to insure close regulation, particularly for engines for use in connection with the generation of electricity. The varying conditions under which engines for this branch of work are compelled to operate are not always appreciated and unsatisfactory results sometimes follow, which may be due simply to lack of consideration of the conditions in question. The writer has recently had occasion to notice the operation of a small trolley line and to remark upon the convulsive efforts of the engine to take care of the suddenly varying loads cast upon it. The line, being a short one, was started with but two motor-cars, but these are at times heavily loaded, and it is most apparent in the neighborhood of the power-house whenever a car is stopped or started on the road, simply by the heavy puffing of the exhaust and sudden laboring of the engine for a few minutes after. This called attention to the fact that, there being but two cars, the fluctuations in the load were much greater than if there were several, as the average work would be much more uniformly maintained if carried to a greater degree of subdivision. As the service increases this will doubtless modify the action, but the motive power, which has probably been installed with future conditions in view, is now struggling with present conditions, and is having a hard time of it.

THE question of the efficiency and capacity of coil boilers has recently had given to it additional data for a favorable answer by the unusually high results which have been attained by the latest Thornycroft torpedo-boat-catcher *Daring*. This boat, which was guaranteed by Messrs. Thornycroft to make a speed of 27 knots per hour, exceeded this guarantee in a most remarkable manner, the average speed of three runs over a measured mile, with and against the tide, being 28.268 knots, and the last of the three runs, although against the tide, was made at the rate of 29.268 knots per hour! While this marvelous result is doubtless due to the entire combination of points, all of which must have contributed to the speed, yet it is worthy of note that the coil boilers furnished ample steam throughout the run, and that the safety-valves were blowing for a portion of the time. Of course no one doubts that coil boilers are excellent steamers and the points about such boilers which have been subject to criticism have been rather those of durability and accessibility, but if the main point of steaming capacity can be demonstrated to be so superior for this type as the above trials seem to indicate, there can be little doubt that the proper application of intelligent study and experience will enable the other debatable questions to be settled beyond controversy for both large and small boilers, and that too without impairing the capacity of the boilers for their real object,—*i. e.*, the making of steam.

AMONG the many interesting features of the Montreal meeting of the American Society of Mechanical Engineers the attraction offered by the Reuleaux collection of mechanical models at McGill University is especially worthy of note. Although this is the most complete set of the Reuleaux models on this side of the Atlantic, yet it does not comprise all the beautiful examples of the model-maker's art which may be seen in the magnificent series at the Berlin Polytechnic, but no one who has seen even a portion of these models can fail to be convinced of the fact that it is by such

means that instruction in kinematics can best be conveyed. When the nature of a kinematic "chain" is once impressed upon the mind through the medium of the eyesight it is almost impossible for the student to misconceive the relation of parts in subsequent combinations, and it is to be hoped that the use of models will extend more and more in this and other branches of instruction. The practical mechanic finds actual working models all about him in his everyday work, and whether he will or no he is obliged to take into account all the functions of the various pieces of mechanism with which he has to deal, so that there can be none of that convenient "neglecting" of quantities or values which the student may intend to determine at some more convenient season. A man educated in the midst of such constant demonstrations as are given by the mere presence of such models as those at McGill cannot fail to be far more practical, while none the less theoretical, than the student who has followed the usual analytical methods, and the combination of both cannot fail to produce most excellent results.

THE accounts which have been received from England of the manner in which Mr. Hiram Maxim's imitation of Herr Dowe's "bullet-proof" cuirass has excited the ire of the military gentlemen who have been made a laughing-stock by the ingenious American, are decidedly amusing. That Herr Dowe has made a cuirass which offers resistance to bullets seems to have been fairly well demonstrated, and when Mr. Maxim declares that he can do the same thing off-hand and offers to give a public exhibition, crowds of interested individuals, both civil and and military throng to see the show. When it appears that Mr. Maxim's "cuirass" is practically nothing more than a quarter-inch plate of the finest steel, the indignation of the crowd, which conceives itself "sold," is great, and Mr. Maxim barely escapes being mobbed. The amusing feature about it all is that the steel plate, which gives equal resisting capacity with the German fabric, weighs somewhat less per square inch than the latter material; and that, notwithstanding this most apparent fact, Herr Dowe protests vehemently, in print and otherwise, that there is no steel in his cuirass. It is possible to sympathize to a limited extent with scientific men who have been gravely testing the German invention, in view of their feelings when they discovered the little point which Mr. Maxim has brought to their notice, but it is difficult to maintain a straight countenance when one thinks of the solemn Germans, objecting to the use of anything so *unwissenschaftlich* as steel, after all the learned discussions which have been given to the new material, even though the latter may be no better than steel and rather heavier.

A CONTEMPORARY journal attempted in a recent issue to enlighten the "public mind" as to the question of the real meaning of the term "knot," and went to some trouble to explain that a knot is not equal to a mile, which indeed is quite true, but in its further effort to impart information it proceeded to state that a knot is 6082 feet long! This confusion of a knot with a geographical mile is not uncommon among landsmen, and indeed is frequently found existing in the "public mind," but the editor of a technical journal should know that, properly speaking, a knot is not a distance at all, but is a *rate of speed!* The only possible sense in which a knot can be considered as a length, is when the distance between two knots on the log-line is meant, which is something quite different. To call a knot a distance of 6082 feet, is about as correct as to call a horse-power 33,000 foot-pounds, the omission of the time element being an error of equal importance in both instances, and, although some of the older dictionaries commit the error of confounding a knot with a nautical mile, yet the later works, which aim at some degree of correctness in definitions of technical terms, are more accurate, and surely a journal which professes to enlighten the public mind should be more careful in such matters.

THE present status of the armor-plate question bids fair to perpetuate the old

logical paradox of the result when an irresistible force meets an immovable resistance, and the solution of the problem seems to be no nearer than it was in the memorable days of Jules Verne's "Baltimore Gun Club." No sooner do we hear of the great success of a test armor-plate than it is followed by the triumph of an armor-piercing projectile, and so the contest will go on until the limit of one or the other is reached. Not so very long ago it was thought that the maximum gun capacity had been reached, but to-day we have guns of much lighter weight with far higher "power," while on the other side improved methods of hardening and the use of nickel alloys have enabled armor-plates of far higher resisting capacity to be made than was formerly supposed possible within practicable limits of weight. It still seems probable that the result will ultimately be the same as it was with armor for man and horse, and that the increase in armor protection will go on and on, until the actual limit is reached, when it will suddenly be abandoned entirely, to make way for speed, agility, aerial warfare, or possibly—disarmament?

THE success which has attended the official trial of the *Minneapolis* is a most satisfactory confirmation of the wisdom of the adoption of triple-screw propellers for fast cruisers, and Mr. Melville is to be congratulated upon the demonstration of the correctness of the faith he has put in this construction. While the greatest argument in favor of the triple screws has been the practicability of using the middle propeller for moderate speeds at high economy, at the same time retaining the enormous power of all three engines and propellers for the high-speed use in commerce-destroying, this has been shown to be only one of the advantages. The *Columbia* showed a decided fuel economy over that of the twin-screw cruisers, as well as increased speed, and the full reports of the detailed performance of the *Minneapolis* will be awaited with interest for additional information upon this point. The merchant marine waited the results of twin screws in naval service before adopting them on the Atlantic lines, but now, in spite of the excellent performance of the single-screw *Umbria*, twin screws are considered the only proper thing for fast transatlantic service. The records of the *Columbia* and the *Minneapolis*, however, lead us to believe that before long triple screw steamers will be winning new records from Sandy Hook to Roche's Point, and that twin screws will have to take second place. The great increase in power which must be provided has caused some parts of the engines to surpass practicable machine-tool limits, but when three engines, driving as many propellers are used, it is possible not only to keep the parts within reasonable dimensions but also to triplicate much of the work, thus permitting many economies in first cost of construction. We have spoken elsewhere of speed and of armor, and in our new navy we have both, and it is not out of place here to call attention to the paper by Engineer-in-Chief Melville, in another part of this Magazine, upon "The Modern Battle-Ship as a Fighting-Machine," and to the rapid manner in which the engineer is superseding the sailor as the operator as well as the constructor of a "man-o'-war."

RAILWAYS

Conducted by Thomas L. Greene.

RAILWAY questions, during the past month, have been overshadowed by the strike of the employés against the roads using Pullman cars. The merits or demerits of the dispute at the town of Pullman have been lost sight of in the face of the much greater problem presented by the general strike. Finding the business of car-building dull Mr. Pullman proposed to his employés a reduction in wages. They apparently consented, whereupon Mr. Pullman accepted contracts for cars at prices so low that on that particular work he lost something on each car. The indirect benefit to the men consisted in that the Pullman company thus afforded them work during a season of depression, though at a reduction below their regular wages. Mr. Pullman's object was, however, not philanthropical; he no doubt was willing to lose a little money if he could keep his town occupied, his plant in order, and his skilled workmen attached to his shops, in order to be ready when business revived. For this he expected such an inflow of orders as would more than make up his past losses. Though the men had apparently accepted the reduction after the contracts were signed they refused to work longer, demanding the increased pay. This Mr. Pullman refused and still refuses to grant. Following this local dispute came the order of the Federation that a general strike should be declared against all companies which used Pullman cars.

WHATEVER judgment one may pass upon the justice of the original demands of the Pullman employés, it is clearly evident that a general stoppage of trains is not a proper way to settle that question. So important is the service rendered by the railways that not only are our modern complex commercial conditions dependent upon transportation for their continuance, but the people of many states must rely upon the railways for bread and meat. In short, our present civilization could not exist without interstate railway commerce. It is monstrous, it is unbearable, that our whole trade should be thrown out of adjustment, in order that a wage settlement, concerning but a few men comparatively, should be forced. The railways could not yield this point; they must fight the fight out for the good of the whole community.

FOLLOWING the precedent set by Judge Jenkins in the Northern Pacific cases, the courts granted injunctions against interfering with the trains. That judge called a combination to quit work on the part of railway-men, a conspiracy to cripple the running of the railways, and, therefore, in the nature of the case, criminal. A trainman or switch-man is bound by the equities of his position. The sailor cannot stop work in midocean, nor the pilot in midstream, nor the policeman while making an arrest, nor the surgeon when in the act of performing an operation. If the running of trains is a necessity of civilization—and even the courts are adopting that view—the railway employé has no more moral right to stop them without notice at the bidding of his trade-union, than has the sailor or surgeon to quit work at any moment. These injunctions are based upon some such idea. But before we can say exactly what line the new theory will take, we shall have to wait for the opinion of the United States supreme court, to which august tribunal the Northern Pacific case was appealed. The calling out of the United States troops was in line with that theory. There is law and precedent for President Cleveland's action. Nor does it violate the spirit of the constitution. When our forefathers conceded to the states their local authority they did

not mean to cover cases where local authority concerned other states. Massachusetts is dependent upon Dakota for bread; it would be a subversion of the spirit of the law if by enactment or failure to enact on the part of the state of Illinois, this flow of breadstuffs across the state should be interrupted. In this view not only is federal interference justified by the existing statutes, but not to interfere for the protection of interstate commerce would be to lose sight of the very thought of the constitution which intended to prohibit the stoppage of trade across state lines by reserving its regulation to congress. Trade has outgrown state lines and the law-making and the law-executing powers must advance with our business progress and be molded by it.

IT is very much to be doubted whether Mr. Pullman's experiment of a town controlled by his company should have been undertaken. It smacked too much of paternalism and gave the employés a chance to say that Pullman was bound to take care of them, since their wages gave a profit to the company in the shape of rent, gas- and water-charges, and the like; and that since the Pullman company as a whole was prosperous enough to continue the old dividends it should pay old wages. Not a convincing argument by any means, nor one which had any bearing on the absurd claim of the Pullman men that the company should arbitrate whether it should continue working at a still greater loss but yet an argument which affects the question of the general policy of that successful company. Pullman's great success has come from two things: his own ability and adroitness in taking advantage of every circumstance, and, next, the disjointed roads which make up our through routes. When several railways agreed to run cars over long distances in time-table connections, it was difficult for them also to agree to furnish the parlor- or sleeping-cars which long routes required and which the public demanded. It was much easier to contract with Pullman for the whole supply. Thus the use of these cars spread, particularly as their great cost (from $18,000 to $40,000 per car) deterred many weak roads from investing the capital required to build parlor- and sleeping-cars of their own. It was simpler to pay Pullman a handsome profit. But strong roads took advantage of Pullman's really weak position to make contracts which left but little profit. Thus the Pennsylvania railroad pays Pullman only the fares he may collect, while systems which were short of money—the Erie is an example—could secure Pullman cars only by paying him two cents per mile run, besides the fares and the usual agreement to keep the outside of the cars in repair. It is apparently inevitable that railways as they become large systems and have more money to invest in their own business, will either run their own parlor- and sleeping-cars to save the Pullman profit, or else demand such contracts from these palace-car companies as will yield them only a moderate dividend. At any rate the railway-managers just now feel a bit sore that they have had to bear the burden of a strike for a Pullman dispute.

THE mileage of new railway built in the first half of 1894 approximates 500 miles, or less than half that built in the corresponding six months of 1893. Of course the hard times will account for the decline in building, though there is a deeper cause also,—the lack of profitableness which railways are now experiencing partly through adverse legislation and partly through sympathy with a decline in profits affecting all industries. The former cause —business depression—it is hoped and believed will not keep our people bound down long; the latter is more far-reaching and will not be overcome in a day.

SOME statistics on the freight-car problem given by Mr. Wheatly before the car-accountants' convention, are interesting and instructive. During the year ending June 30, 1892, figures compiled from the interstate commission's reports show that private cars (cars not owned by the railroads) earned $14,269,405—and ran an average of seventy-five miles per day, for 70,000 cars. Each car thus earned on the

average $200 per year or about 25 per cent. on its cost. Computations based upon the same reports give the average mileage of railway-cars at 23 miles per day, or but one-third of that made by private cars. One should not draw comparisons between these figures without remembering that private car companies have built their cars for trades which require rapid running and that if live-stock and refrigerator cars belonging to the railways were alone considered, their daily mileage would be much above twenty-three miles. Still it is a notorious fact that private cars are more carefully looked after and it is also said—how truthfully cannot now be vouched—that one reason why the railroads run them is that railroad officers are interested in the profits. Probably a more important reason for their hold upon the railways lies in the fact that mileage payment for private cars covers what is practically a rebate to the shipper. While we cannot eradicate rebates until we have some form of pooling, on a fair division of traffic or earnings between competing lines depends a great many reforms which would save the carriers considerable sums of money, while also doing away with that worst of all discriminations, the discrimination in transportation charges between one merchant and another.

THAT low average mileage of twenty-three miles a day for common freight-cars brings up a most serious problem in railway economics. If we estimate that a freight car costs $700—at 5 per cent., the interest charge yearly would be $35—then adding to this (say) $45 for depreciation (assuming that the life of a car is twelve to fifteen years) we have $80, that a freight-car must earn annually before profit begins. At twenty-three miles per day the yearly mileage of such a car is 8400 miles, which at ¾ of a cent amounts to $63. If, therefore, such a car were loaned out to other companies for the whole year, it would stand the owner in for a loss of $17. And certainly, though it may be run on its owner's road and carry first-class goods at high tariff rates, such a record shows bad economy. We have indeed touched a sore spot. We cannot divide the ton-mileage by a car's capacity and say that only so many cars are needed, for other things are to be considered. Traffic flows unequally on every road, as evidenced by the fact that throughout the United States empty cars constitute 29 per cent. of the whole car mileage. Again, cars must be sent where traffic is heaviest, which may come in turn at different places, necessitating the transfer of cars. Yet, when all is said, it is plain that we have perhaps a fourth more freight-cars in the United States than are necessary to do the business. The advantage of such a company as Pullman's is that he can mass his whole equipment where there is need for it, now in Florida and then in California. In short, if the railways are to manage their freight-cars properly they must have some sort of organization which shall control the equipment to the best advantage—a car clearing-house or something of the kind which might begin in some traffic association's territory.

ANOTHER paper of interest was that on demurrage, read by Mr. Simmons before the car-service managers. The practice of charging for delays to loaded cars is one for which strong arguments may be advanced. One reason for the small mileage of freight-cars just mentioned is, no doubt, their use for storage. Carriers are undoubtedly entitled to receive back their empty cars within a reasonable time. This principle is recognized in all the railway tariffs of Europe, which also provide a penalty for every day's delay to the property of the shipper and thus make the obligation reciprocal. But the time allowed for transit in Europe is about twice that taken on the average by American railways for the same distance. Hence the adoption of European methods would not suit our better service. The better way out of the dilemna is to admit the right of the carrier to demurrage after an unreasonable delay to the car; what is an unreasonable delay to be ascertained according to the circumstances, the kind of traffic carried, etc. But an element of injustice in any such scheme for demurrage was the prac-

tice of charging for delayed cars without giving credit for cars promptly unloaded. This led to the device explained in Mr. Simmons's paper, which has been successfully tried in Philadelphia, Cleveland, and elsewhere. This device is to calculate demurrage upon the plan of averaging the twenty-four hours. Under this plan both small and large shippers who can release certain of their cars quickly are invited to do so in order to offset such detentions as will inevitably happen to some cars during the month. If the average detention is within the prescribed limits, no demurrage charge is made. Any arrangement which is of mutual advantage to consignee and carrier and which avoids friction between them, is worthy of imitation, particularly at those places where friction about car detention is frequent and warm. The plan is also made the reason for a demurrage contract to be signed by both parties, thus removing misunderstandings.

In the Master Mechanics Convention there was an interesting discussion on the question of the cost of maintaining locomotives—whether greater for those built in the shops of the railways or for those bought by contract. Evidently there was not enough information to enable such a question to be answered satisfactorily, and it would be well, therefore, to postpone judgment until more is known. In the first place, engines differ from each other in style and capacity enough to vitiate any comparison unless just the same class of engines is taken in each case. In the same way, comparisons should not be made between freight- and passenger-engines since the service, and, therefore, the cost of repairs, is not the same. It is well known, too, that the speed of trains affects not only the cost of repairs but the cost of running a mile, so that comparisons between the engines of different railroads are of little value unless we know that we are comparing exactly the same conditions in each case.

Nevertheless, when all is said, it was the opinion of the committee that locomotive-building in the railroad-shops was cheaper to maintain, although all the figures quoted were not to the same effect. In one case six switching-engines built by contract cost 2.25 cents per mile for twenty-two months, while engines of the same class built by the railroad company cost 2.32 cents per mile for thirty-one months,—a difference, it will be observed, in favor of the contract-built engines. In another case, twelve railroad-built engines cost 3.59 cents for repairs against 3.62 cents per mile for contract-built locomotives,—a difference in favor of the former.

Coupled with this question is the further one whether the first cost of engines built in railroad-shops is more or less than that of engines built by contract. The committee expressed no opinion. The off-hand view of twenty-five roads was asked, of which eight replied that it was cheaper to build engines, three that there was no difference, and eight that it is not cheaper to build. The question, therefore, is left in abeyance, as nothing is proved by such figures. It is probably true that there does not exist any information of sufficient value to determine such questions. It is largely a matter of experience in each individual case. While it is undoubtedly true that engines, under certain conditions, may be built more economically in a railroad-shop, it is probably equally true as a general proposition that in the long run a railroad company will gain by having its engines built under contract by a reputable maker. It is coming more and more to be believed that the business of a railroad is transportation, pure and simple. That is their specialty—not the making of cars and engines. Companies usually now let out their construction by contract-work to men who make a business of building track or houses, and who have the necessary skilled workingmen, tools, and experience, as well as the material. It is not an extravagant prophecy to say that in the future the evolution of the railroad problem will lead the companies to confine their operations to the loading and hauling of passenger- and freight-cars, leaving everything else to be furnished by those who make a specialty of the matter in each case. As we know, the professions of law and medicine are cut up into spe-

cialties where experts work and devote their lives to one particular branch of their profession, and, while the great business of a railroad company can not be compared directly to medicine or law, yet it is probably true that the same principle will work itself out slowly, and that in time we shall see not only the furnishing of our cars and engines, but also the heavy repair-work done in separate establishments by those who will thus be enabled to do the building and repairing more cheaply and expeditiously.

THE Union Pacific railway bids fair, before we are done with it, to prove the most tangled problem in our railway finance. The government loan, which is a second mortgage on the main line, begins to come due in 1895. The first mortgage on the line, amounting to $33,000,000, matures at about the same time. The collateral trust notes must be treated this fall. Altogether the business questions are pressing ones. As is well known, the larger part of what is called the Union Pacific system is made up of branches which, in any case, are important railroad corporations in themselves. The bonds of all these branch railroads are in default and committees are being formed to demand for each class of bonds the largest possible share under any plan of reorganization. It is a well-known fact, brought out again lately in a petition of the receivers to the court, that the greater part of these branch roads do not of themselves earn their fixed charges. At first blush it would seem to be an easy matter to say let all such branch roads as do not earn their interest charges be cut off from the main line, but unfortunately for this view a careful series of compilations made during the time of the investigation by congress in 1887, and again lately, show that about one-third of the combined net earnings of the main line come from the carriage of traffic received from or delivered to the branch roads. If these branch roads were cut off, and if this interchange traffic were lost to the main line, that main line would only earn money enough to pay the first mortgage interest, leaving the government with its second mortgage practically worthless. It is evident, therefore, that the federal authorities, for their own sakes, to say nothing of the stockholders, can not afford to press upon the bankrupt company any such policy as would diminish the net earnings. On the other hand, as matters stand now, these branch roads are dependent upon the main line for an outlet. Some talk has been heard, indeed, of these various branch lines forming a new company by themselves and building another main line to connect them, and thus leaving the government to wrestle with the then worthless main line. While such a scheme is of course a possibility, it is hardly probable that the owners of the securities of these branch roads can be induced to take such concerted action as would place them in the most favorable possible position to demand their full mortgage rights. Besides that, Uncle Sam can not be treated like an ordinary creditor. All things considered, it would be part of wisdom for congress to fund the government debt on long time and at favorable rates of interest, leaving the rest of the creditors of both the main and branch lines to arrange their differences as best they can. The moral argument is also a strong one. The government loaned its credit to the Union Pacific at a time when no one supposed the building of such a line would be commercially profitable. The money was indeed invested by the federal government as a political measure. Certain men made large sums out of the Union Pacific, but it may be urged that they were entitled to a fortune for the pluck and energy which they displayed in the face of great obstacles. The fact that there was scandal connected with the building of this company does not affect the main argument. Under the best of circumstances a reorganization of this great system would require the greatest care and thought.

COMMENT & CRITICISM

A Defense of Henry George.

A REMARK made by Mr. William Nelson Black, in his article on "The Coxey Crusade and its Meaning" in the Magazine for June, seems to call for some comment. Let me say first, that I agree with the main conclusions of Mr. Black's article, but when he classes Mr. Henry George's proposition (to tax land, exclusive of improvements, at its annual rental value, abolishing all other taxes) with Populism and State Socialism he goes very wide of the mark. Moreover, when he says that "Sixty millions of peasantry in Russia with hardly intelligence enough to keep them from starvation, are living, as possibly their ancestors for a thousand years have lived, on lands held by substantially the same tenure advocated by Henry George in his 'Progress and Poverty,'" he makes a statement which has been made many times before and effectually answered.

I need not take up your valuable space with a detailed answer at this time, especially as it is sufficient to call attention to the fact that the Russian peasantry are regularly robbed, by taxation and otherwise, of all they can produce above the meanest and poorest living. On the contrary, Mr. George's plan would leave in the possession of producers *all* that they produce, and would require them to pay into the public treasury only the amount representing the advantage enjoyed by the possession of specific locations as compared with less favorable locations—a value created entirely by the community. In other words, all those who do useful labor of any kind, mental or physical, would be left in the full enjoyment of the results of that labor, and would be free to make such exchanges with other producers in this or any other part of the world as they may choose; each one being charged by government only for the bare annual site value of the particular portion of the earth's surface occupied by him. Does Mr. Black think that, under these conditions, men who work will be in a position resembling in any way that of the Russian peasantry?

Having made some examination of Mr. George's proposition, I am convinced that his plan would be very decidedly in the interest of all those who by mental or physical labor perform services that are of use to others, and that the only ones whose interests would be injured by it would be those who do not do this but who simply charge others for the privilege of doing it—and charge "all the traffic will bear." While I consider Mr. George's argument and logic unanswerable, I do not of course deny the right of others to dissent from them, but they should at least acquaint themselves with the subject before going into print regarding it.

J. K. MILLER.

Plainfield, N. J., June 22, 1894.

[WE had intended to exclude any further controversy over Mr. George's proposals, for the reason that the subject was discussed at length in these pages about a year ago by Mr. Black and Mr. E. J. Shriver. For the purpose, however, of stating pointedly just why THE ENGINEERING MAGAZINE is unalterably opposed to Mr. George's scheme, and why we regard Mr. Black's statement of the case as substantially correct, we have concluded to answer Mr. Miller's communication.

As the New York *Evening Post* observed about two years ago, there is no theoretical objection to the single tax as a means of raising the revenue necessary to government economically administered, but on the contrary there is much to be said in its favor. It is, however, an ideal system of taxation which has been before the world more or less prominently time out

of mind, but because people everywhere greatly prefer systems of indirect taxation, it has rarely been adopted, and never enforced for any length of time.

But a single tax *limited to the necessities of government* is very radically different from what Mr. George proposes. Starting with the amplified declaration that private property in land is *robbery*, he deliberately proposes that all land-values shall be confiscated by the State. Far from qualification or reserve, he is frank, open, and even boastful in the declaration that each and every landholder is a robber, and that the government has not only the right, but owes it as a duty to the people, to confiscate the last farthing of land-values that can possibly be collected, after the complicated process of excluding improvements on the land has been gone through with. If Mr. Miller or any of his sympathizers desires specific authority for this representation, they are referred to the pages of "Progress and Poverty," and especially to page 364 of book VIII, where he says:

> We may safely leave them (the land-owners) the shell, if we take the kernel. *It is not necessary to confiscate land; it is only necessary to confiscate rent.*
>
> No owner of land need be dispossessed, and no restriction need be placed upon the amount of land any one could hold. For, rent being taken by the state in taxes, land, no matter in whose name it stood, or in what parcels it was held, would really be common property, and every member of the community would participate in the advantages of its ownership.

Now the confiscation of land-values after this fashion would, of course, aggregate an enormous revenue, far in excess of the needs of government. To make use of this great surplus, Mr. George comes forward with the socialistic proposal that the government shall buy and operate the railroads and the telegraph; that in the cities we shall not only have municipal electric, water, and gas-works, but that the local politicians shall also run free street-cars; that we shall have great free libraries, magnificent public baths, after the fashion of the Romans; and, somewhere in his writings, he advocates the altogether novel and picturesque idea that milk shall be distributed about the cities in underground pipes.

In short, Mr. George maintains that all right and title to land vests in the state, and not in the individual who occupies and uses it; and straightway he proposes a plan of asserting that right by means of confiscation through the single tax. The Czar likewise maintains that all right and title to the land of Russia is vested in the people, represented by himself, rather than in the individuals who occupy and use it; and while his plan for asserting that right differs somewhat in method from Mr. George's, in effect it asserts the identical principle as to land-tenure. Hence our approval of Mr. Black's statement of the case.

Fundamentally, such a system is in error because it ignores the obvious fact, proved by all history, that exclusive private property in land is not only the best but the most beneficent institution that civilization has yet adopted. But for the right of the individual to absolutely own and control that land which is necessary to his use, the civilization we enjoy to-day would not have been possible. There is, indeed, immediate and great need of some wise legislation to restrict the ownership of land which is neither occupied nor used. This is apparent to every thoughtful man who has looked into the subject; and the next step in the way of land legislation must be towards a return to the spirit and letter of the Homestead law, under which our vast public domain has been taken up, not by settlers, as was intended, but by speculators who now hold vast tracts of it out of use solely for speculative purposes. But legislation of this kind is very far from the wholesale confiscation proposed by Mr. George, and it is diametrically opposed to his fundamental tenet that property in land should vest in the state—in other words, that we should return to the primitive, socialistic organization of the Jews, Greeks, and Romans. —THE EDITOR.]

CURRENT TECHNICAL LITERATURE

THE MINERAL INDUSTRY: ITS STATISTICS, TECHNOLOGY, and Trade. Volume II. Edited by Richard P. Rothwell. New York: The Scientific Publishing Co. [Cloth. 8vo. xl-864 p. $5.]

FOR many years the *Engineering and Mining Journal* issued annually an extra supplement containing the statistics of the mineral industry for the preceding year. This supplement grew in time to be such an important feature of the *Journal* that it was decided not only to put it in book form, but to widen the scope of the statistical inquiry for the United States and, in addition, to give the statistics of foreign countries. When, early in 1893, the first volume thus compiled was issued, it was a surprise to even the most sanguine believers in the statistical and technical ability of the editor, Mr. Richard P. Rothwell. It was unheard of that an individual should have the courage and enterprise to carry out a work which involved even greater labor than the preparation of the government census on the same subjects, and, more than this, collecting data from every country in the world in addition to those from the United States, and also to present a series of articles on the existing condition of various mineral industries, each written by a recognized authority. It is, furthermore, the only work published in any language that gives the statistics of the mineral industry of the world.

The second volume of this work brings the statistics up to the close of 1893, and covers even a wider range in its technical articles, than did the preceding volume. It is impossible here to give such a review as each of the articles deserves. Among those from well-known authorities is one on aluminum, by Joseph W. Richards, which gives a comprehensive review of the improvements made in manufacturing this metal during 1893. A contribution on arsenic by William Thomas, secretary of the Mining Association and Institute of Cornwall, is a valuable addition to the literature on this subject. One of the most exhaustive and valuable articles is that by A. M. Gibson, on the history of alkali manufacture in Great Britain. Another article, covering as wide a scope, is that upon clay, by Heinrich Ries, which gives a mass of information not available from any other source. Coal is fully treated by H. S. Fleming and some instructive diagrams of the world's production and consumption of fuel are given. Upon copper there are two articles which treat the metallurgy of that metal up to present practice,—one by the well-known authority, Dr. Edward D. Peters, Jr., and the other, upon American practice in electrolytic copper-refining, by Titus Ulké. This latter article is the first which has yet treated this important subject exhaustively, and is therefore worthy of particular note. The article on gold and silver betrays Mr. Rothwell's careful supervision in its accuracy and comprehensiveness. Iron and steel, with the advances made in their metallurgy during 1893 are carefully treated. Two valuable papers by W. R. Ingalls treat, one on the distribution and production of lead, and the other on the present condition of the zinc industry in Europe. Another valuable contribution is that on petroleum, showing the condition of this industry throughout the world and concise information as to the processes of refining and preparing it for market. Robert H. Richards, writing on the progress in ore-dressing in 1893, gives a brief review of the various important improvements made in this branch of metallurgy during the year. No mention can be made of a large number of other articles of no less interest and value.

Even the briefest review of the work would be incomplete, however, without reference to the astonishingly complete set of statistical figures as to the produc-

tion and consumption of various minerals in the United States and other countries. Their general arrangement, which is better than that in Volume I, coupled with an unusually complete index, permits reference at a moment's notice. And a priceless feature of the work consists in the fact that when reference is made to these statistics, one can rely upon their accuracy. Such information is almost invariably published by national or state governments, and the work is done by men in whom the prime essential of fitness is that ability and alertness at political wire-pulling which will secure appointment. The consequence is that governmental statistics are, with very rare exceptions, notoriously inaccurate and they are invariably months or years behind with the publication of the information desired. In this case, however, the only possible hope of reward to either publishers or editor must come throngh the reputation for accuracy and promptness which the book itself makes. For this reason we feel warranted in the statement that no other statistical work of equal magnitude has ever before been produced, which rightly commands and fully deserves the commendation and confidence of so wide a circle of trained readers and skilled statisticians. It indeed ranks preëminent as the source of such information in its particular field; and by virtue of the high reputation which it has already attained, and the evidences of profit which its repetition and rapid expansion indicate, we regard it as the forerunner of a radical and needed change in the direction of taking such important work out of the hands of goverment, to the end that the field may be open for the free competition of those whose actual accomplishments distinguish them as the ones best equipped to conduct such enterprises.

COAL DEPOSITS OF IOWA. VOLUME II OF THE REPORTS of the Iowa Geological Survey. By Charles Rollin Keyes. Des Moines: Published by the Survey. [Cloth. 4to. 536 p. with maps.]

COAL is by far the most important item of mineral wealth in Iowa. In that state the coal-measures have an area of over 20,000 square miles, or counting the workable area at one-half, the coal-bearing territory equals in area that of Great Britain, is three times as great as that of Germany, and four times that of France and Belgium. The coal does not occur in very heavy beds, but for the most part lies comparatively near the surface and is easily and cheaply mined. This report is the first authoritative account of the Iowa coal-deposits, and it is intended to be followed by other reports in more detail, as systematic exploration progresses. It is prepared with a view to popular use, and will be of much value to those engaged in the local coal industry, as well as to outside investors seeking reliable information on the subject. In an introductory chapter stress is laid on the vast economic importance of coal supplies, and on Iowa's favored position in this respect. Chapter II discusses the origin and mode of formation of coal and the associated beds. Then follows a description of the whole carboniferous basin of the Mississippi valley (in which, by the way, there are some slight inaccuracies as to the western plains region), and of the general geology of the coal territory. A chapter is devoted to the lithology, and another to the stratigraphy, of the coal-measures. Succeeding chapters treat of the coal-beds opened in the several counties of the state, and the accompanying sections are very interesting. The question of waste in coal-mining is considered in some detail under the heads of waste due to methods of mining, in removal of coal, and in fine coal. The volume concludes with an exhibit of the extent of the local coal interests, growth in production (from 48,263 tons in 1859 to 4,047,479 tons in 1892), number of mines and value of product, mining localities, present territory supplied, and markets. The report is well gotten up and handsomely illustrated.

TELEPHONE LINES AND THEIR PROPERTIES. By WILLIAM J. Hopkins, Professor of Physics in Drexel Institute, Philadelphia; New Edition Revised and Enlarged. New York: Longmans, Green & Co. [Cloth. 12mo. xvi-272 p. $1.50.]

THE literature on telephony in America is so scant that no one interested in the subject can fail to accord to any work

bearing on telephone practice a hearty welcome—even to a work containing so many defects as this does. Even though the author partially disarms criticism by his *naif* confession in the preface that "the subject of exchanges has been taken up principally to round out the scope of the book," one can scarcely excuse the presence of much matter that gives continual evidence of a lack of practical acquaintance with the subject. The defects of the book are almost entirely due to this lack of practical knowledge, which in many places leads to extremely superficial remarks on matters of importance, in others to giving obsolete information an air of modernity, and in still others to absolute inaccuracies. The peculiar conditions under which the telephone industry in this country flourishes militate against the production of works on telephony by those who alone have the requisite knowledge and experience, so that a text-book on the subject for American readers is not to be looked for in the near future. So we must put up with what we can get. From the reviewer's point of view, however, Professor Hopkins has made a decided mistake in "rounding out the scope" of his little work with matter that is certainly not new and in cases no longer true. Where he writes from his own knowledge and experience he is admirable and that portion of the book to which the title truly applies should be studied by every young telephone engineer.

Chapters I, II, and III, on "city lines," "underground work," and "long-distance lines," give a fair summary of the practice they refer to; by far the best of the three is the chapter on the building of long-distance lines. The remarks on cables are sadly incomplete and those on distribution of lines are sadly out of date. Chapters IV, V, VI, and VII deal with "wire," "insulators," "exchanges" and "switchboards." Those on "wire" and "insulators" are good and practical; those on "exchanges" and "switchboards" might better have been omitted altogether. Chapter VIII, on "the propagation of energy" is inserted because the author's intention was to make the book "useful to the practical man as well as that it should serve as a basis for a lecture course to students." The very title of the chapter would strike terror into the soul of the "practical" man, as we know him, and students would probably go for such information to sources where it is more fully dealt with. Chapters IX to XIII, dealing with "the telephone current," "measurement," "properties of city lines," "interference from outside sources" and "properties of metallic circuits," are by far the best part of the book. They contain a clear exposition of the properties of telephone lines, and much special information that is to be found in no other book; here the author is evidently in his own element and no telephone engineer can fail to follow him with profit. Chapter XIV (and last), on "cables," is open to criticism on the score of superficial and out-of-date information. The book closes with two appendices: one an interesting little essay on (electrical) "oscillations," the other a reprint of a paper on telephone induction read in 1891, before the American Institute of Electrical Engineers, by Mr. J. J. Carty, to whom Professor Hopkins acknowledges his indebtedness for a fair proportion of the information in the body of the book.

The present edition is styled "revised and enlarged." The next edition should be revised and reduced. The matter here criticised as obsolete and superficial should be omitted entirely, and the book would be greatly the better for it; to the telephone man it would be more readable, to the student it would be more valuable. By such a revision and by the editing of sundry matters of detail by a practical telephonist Professor Hopkins would secure a book which would bear out its title and fulfil its purpose far better than the present volume. From a literary and mechanical point of view the book is an ornament to technical literature.

HERBERT LAWS WEBB.

AMERICAN STREET RAILWAY INVESTMENTS. (ANNUAL Supplement to *The Street Railway Journal*) For Bankers, Investors and Street Railway Companies. New York: The Street Railway Publishing Co. [Cloth. 4to. 216 p. $5.]

NOTHING that could be asked for in a reference-book for the use of investors or

intending investors in street-railway securities has been omitted in the compilation of the work above described. The utmost pains seems to have been taken in compiling the statistics of capitalization, the physical condition and the details of operation of all the street railways in the United States. This field, though but recently developed, is a most promising one for judicious investors, and this volume is the first comprehensive guide to those who are interested in this field. The book will be found none the less valuable to engineers who are engaged in street-railway construction or are contemplating such work.

THE OFFICIAL RAILWAY LIST: A COMPLETE DIRECTORY of [all officials of] Railways in North America, and Handbook of Useful Information for Railway-Men. Chicago: Railway Purchasing Agent Co. [Cloth. 16mo. 340 p. $2.]

A WORK of great completeness, and bearing evidence of trustworthiness, which, while not technical in character, deserves mention here because of the interest which it will possess for all readers of the Magazine who have any sort of business relations with railway companies. This is the thirteenth annual edition.

THE SOIL IN RELATION TO HEALTH. By H. A. MIERS, M. A., F. G. S., F. C. S.; and R. Crosskey, M. A., D. P. H. London: Macmillan & Co. [Cloth. viii-135 p., with diagrams.]

THIS little book is a model of its kind. As set forth by its authors it is not only for medical men, but for laymen as well. It is meant to impart enough knowledge of the earth—its formation, surface, water-supply, germs, and the diseases they produce which are peculiar to certain localities, its relation to the air both above and in the soil, etc.,—to be of practical value to the individual in deciding (1) what community he shall seek as a home, and (2) in what part of that community he shall locate his house. Chapter I treats of "rocks and soils," the two great divisions of rocks (the igneous and the aqueous) being described. What is of more importance is that the character of the soils formed by the disintegration of these several rocks is defined; so that, knowing the rock formation of any district, one can form some idea of the nature of the soil there. In chapter II, on "humus and micro-organisms," the formation of the surface soil, the micro-organisms therein contained, and the diseases they cause, are discussed. Stress is laid upon the fact that the surface soil is composed, not only of inorganic matter, but of the products of decomposition of animal and vegetable matter. The soil may contain, therefore, the germs producing malaria, diphtheria, typhoid fever, and other dangerous diseases, so that it becomes of first importance to know what soils favor the growth of the micro-organisms that produce these diseases. The "distribution of water in the soil" is next treated, with reference to the carrying of infection by means of the water-supply. Next the book gives "the constituents of water" from the different rock formations and different soils, and their significance. The chapter on "the soil in relation to air" treats both of the air above the surface and that in the surface of the ground, and their relation, and shows how soils of different nature may affect the climate and indirectly the healthfulness of any region. Finally a chapter is devoted to "the geological distribution of disease." Taken altogether, as a "small book on the principles of geology in so far as they concern sanitary science" this volume cannot be surpassed. For the home-seeker it contains a great number of practical facts in a very small space.

A. E. DAVIS, M. D.

NEW BOOKS OF THE MONTH.

Bowley, A. L.=A Short Account of England's Foreign Trade in the Nineteenth Century, its Economic and Social Results, with Statistical Diagrams. (Social Science Series.) New York: Scribner. [Cloth. 12mo. 8-152 p. $1.]

Britten, F. J.=Former Clock- and Watchmakers and their Work. New York: Spon & Chamberlain. [Cloth. 12mo. 397 p. $2.]

Brown, G. P.=Drainage Channel and Waterway; a History of the Effort to Secure an Effective and Harmless Method for the Disposal of the Sewage of the City of Chicago, and to Create a Navigable Channel between Lake Michigan and the Mississippi. Illustrated. Chicago: R. R. Donnelley & Sons Co. [Cloth. 8vo. 480 p.]

Conder, Josiah.=Landscape Gardening in Japan. New York: Scribner's, *importers*. [Cloth. 4to. 2 vols. 61 p., 40 pl. $25, *net*.]

Graham, Maurice.=Practical Hints on the Construction and Working of Regenerator Furnaces. New York: Spon & Chamberlain. [Leather. 16mo. 131 p. $1.25.]

Iles, George.=A Class in Geometry: Lessons in Observation and Experiment. New York and Chicago: E. L. Kellogg & Co. [Leather. 12mo. 46 p. 10 cents.]

Kingsley, C.=Town Geology. New York: Macmillan. [Cloth. 16mo. 239 p. 50 cents.]

McCain, C. C.=Compendium of Transportation Theories. A compilation of essays upon transportation subjects by eminent experts. Publication of series under direction of C. C. McCain. Washington: Kensington Publishing Co. [Cloth. 8vo. 3-295 p. $2.]

McKinney, W. M., *editor*.= American and English Railroad Cases. A collection of all the railroad cases in the courts of last resort in America and England. Vol. LIV. Northport, N. Y.: E. Thompson Co. [Sheep. 8vo. 735 p. $4.50.]

Macvane, S. M.=The Austrian Theory of Value. Philadelphia: American Academy of Political and Social Science. [Paper. 8vo. 41 p. 25 cents.]

Marshall, H. Rutgers.=Pain, Pleasure, and Æsthetics. An essay concerning the psychology of pain and pleasure, with special reference to æsthetics. New York: Macmillan. [Cloth. 8vo. 364 p. $3, net.]

Miller, J. A.=An Outline of Qualitative Analysis. A laboratory manual. New York: Scientific Publishing Co. [Cloth. 12mo. 58 p. $1.50.]

Newcomb, Simon.=The Problem of Economic Education. Boston: G. H. Ellis. [Paper. 8vo. 2-27 p. 25 cents.]

New Republic (The).=A scheme to abolish poverty. The Anti-poverty society of the American plan; social democracy. New York: The New Era Publishing Co. [Paper. 24mo. 2-62 p. 25 cents.]

Palgrave, R. H. Inglis.=Dictionary of Political Economy. Containing articles on the main subjects usually dealt with by economic writers; with explanations of legal and business terms, which may be found in their works, and short notices of English, American, and foreign economists, and their chief contributions to economic literature. Vol. I. New York: Macmillan. [8vo. 800 p. $6.50, net.]

Peddie, William.=A Manual of Physics for Higher-Grade Students. New York: Putnam. [Cloth. 12mo. 514 p. $2.50.]

NEW TRADE CATALOGUES.

Any of these catalogues free on application to the manufacturers.

A. Falkenau, Philadelphia.=Superior 14-in. Lathes, Grinding Machinery, Hydraulic Machinery, Special Machinery. 20 p.

Albert & J. M. Anderson, Boston =Electric Railway, Light, and Power Specialties and Material. 38 p.

Johnson Engineering and Foundry Company, New York.=Hydrants, Valves, Special Castings for Water, Gas and Steam. 16 p.

J. T. Connelly, Milton, Pa.=Railway, Steamship and Stationary Engine Appliances. 32 p. [Improved mechanical devices, new design of locomotive boiler, etc.]

Roberts Manufacturing Company, Pittsburgh, Pa.=Patent Detachable Steel Link Belting, Sprocket Wheels and Shafting. 32 p.

The Sterling Company, Chicago.=The Sterling Water Tube Safety Boiler. 80 p. [An artistic publication descriptive of the Sterling Water Tube Boiler, containing also in compact and convenient form, items, tables and facts of general interest to those connected with the generation of steam.]

Sebastian Lathe Company, Cincinnati.=Descriptive Catalogue Machinery, Tools and Supplies. 47 p.

Dodge Manufacturing Company, Mishawaka, Ind.=General Catalogue Hangers, Pillows, Blocks, Friction Clutch Pulleys, etc. 70 p.

Bass Foundry and Machine Works, Fort Wayne, Ind.=Improved Bass Corliss Engines. 79 p.

The Chapman Valve Manufacturing Company, Indian Orchard, Mass.=Gate Valves and Fire Hydrants. 146 p. [Descriptive price-list of valves. Also contains articles on steam, electricity and refrigeration by well-known authorities, together with an engineering appendix containing valuable rules, tables, etc., compiled from standard authorities.]

Siemens & Halske Electric Company of America, Chicago.=General Catalogue. 160 p. [An exhaustive publication describing various electrical machinery and appliances manufactured, with directions for care of dynamos.]

Central Electric Company, Chicago.=Illustrated General Catalogue. 525 p. [A handsome and well-gotten up publication.]

Builders Iron Foundry, Providence, R. I.=Our Share in Coast Defence. Part II. 55 p. [Brief description of the manufacture of cast-iron bodies for 12-inch breech-loading mortars. Of interest to mechanical engineers and those following advanced foundry and machine shop practice.]

Hogan Boiler Company, Middletown, N. Y.=Quarterly Boiler Review. 18 p. [Discussion of circulation of water in steam boilers.]

The Huyett & Smith Manufacturing Company, Detroit, Mich.=General Illustrated Catalogue, No. 28. 125 p. [General Description of the Huyett & Smith Hot-Blast Furnaces, together with suggestions for heating and ventilation.]

W. & L. E. Gurley, Troy, N. Y.="As in a Glass." [A handsome souvenir publication descriptive of the civil engineers' and surveyors' instruments made.]

F. C. Austin Manufacturing Company, Chicago.=Municipal Machinery Catalogue. 32 p. [Gives full descriptions, with illustrations of street sweepers, sprinklers, rock crushers, etc., of interest to those concerned in care or construction of paved roads or streets.]